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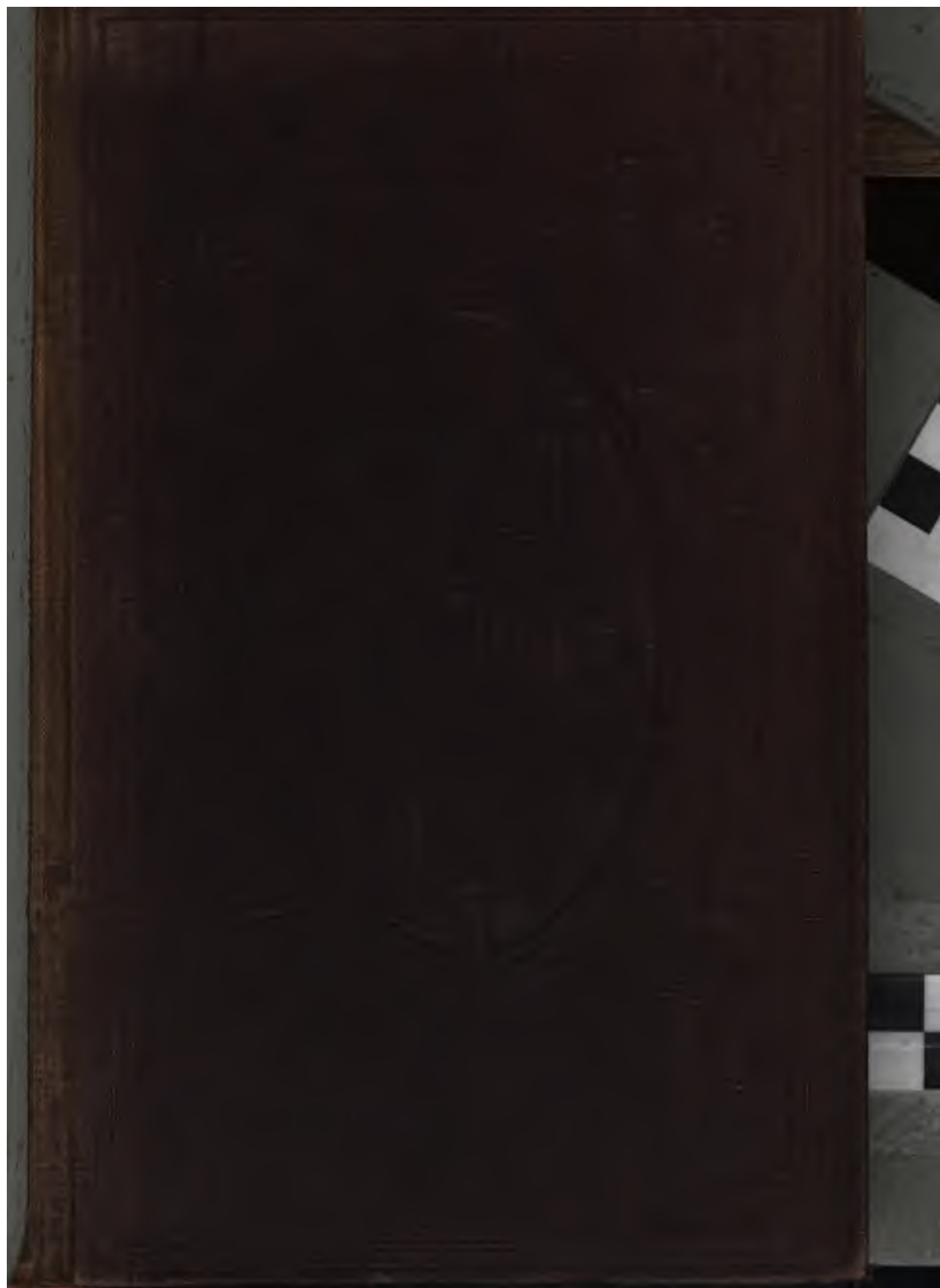
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THIRD AND FOURTH

ANNUAL REPORTS

OF THE

Geological Survey

OF

INDIANA,

MADE DURING THE YEARS 1871 AND 1872,

BY

E. T. COX,

STATE GEOLOGIST,

ASSISTED BY

PROF. JOHN COLLETT, PROF. B. C. HOBBS, PROF R. B.
WARDER, AND DR. G. M. LEVETTE.

State of Indiana

INDIANAPOLIS:

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1872.

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УДАЛ. И ОБРАТЧ

OFFICE OF STATE GEOLOGIST,
INDIANAPOLIS, INDIANA,
December 1st, 1872.

*To the Honorable President and Members of
the Indiana State Board of Agriculture:*

SIRS:—I herewith submit to your honorable body my
Third Report of progress in the Geological Survey of the
State, embracing observations made during the years 1871
and 1872.

Very respectfully,
E. T. COX,
State Geologist.

INTRODUCTION.

It gives me pleasure to be able to note the continued prosperity and rapid extension of our mining and manufacturing industries. Districts that were but yesterday covered by a primeval forest, or only broken here and there by the quiet pursuits of the husbandman, have been awakened by the whistle of the locomotive and the puffs of the stationary engine; coal-begrimed miners throng the streets of mining villages of a year's growth, and the work of mining and shipping coal is pushed forward with an energy and zeal that is unprecedented in the West, and far outstripping the hopes of the most sanguine utilitarian.

The number of mines in the block coal region have greatly increased in all the counties, and it is gratifying to know that the demand for coal is still greatly in excess of the supply.

The benefits derived from this invaluable fossil fuel are not confined alone to the limits of the coal field, but by means of the numerous railroads which penetrate its domain, all parts of the State, as well as the leading cities of the neighboring States—Chicago, St. Louis, Cincinnati and Louisville—have their manufactures stimulated by this most valuable of all minerals.

At the present rate of progress of mining in Indiana, a few more years will develop an endless chain of mines over the entire area of the coal field from Warren county on the

north to the Ohio river on the south, with a belt of blast furnaces girdling the zone of block or iron-smelting coal.

The old iron furnaces are all in blast and making good yields of iron. Arrangements are being made to build a new furnace to be placed beside the Brazil furnace, which is to be blown by the machinery originally designed to run two stacks. Another is to be built at Terre Haute by the Vigo Iron Company, and one has already been built at Shoals, in Martin county, which will use, principally, the native ore referred to in my Report of 1870. This ore occurs in great abundance in Martin county, and the semi-block coal found in Sampson Hill, a short distance southeast of Shoals, will supply it with fuel.

It is also highly satisfactory to know that, by making known the extent and economical value of the minerals, the Survey has had the effect to stimulate mining and manufacturing interests wherever it has been carried. I might further illustrate this by citing the increased activity in mining operations which it has brought about in Daviess county. At Washington, in this county, mines have been in operation since the opening of the Ohio & Mississippi Railroad in 1856, and the business had grown to fair proportions, but I think it may be said, without fear of exaggeration, that coal mining has received an impetus and operations in that line have increased with a rapidity heretofore unknown. Lands which were rated at fifty and one hundred dollars per acre, have advanced to two and three hundred dollars per acre, and capital from various parts of the country has been turned to this county for profitable investment. Instead of having their mining operations restricted to one seam—the “Washington coal”—the Survey has pointed out the existence of not less than eight distinct seams, five of which are, locally, of workable thickness.

The following named counties have been surveyed in detail: Perry, Dubois, Pike, Parke, Dearborn, Ohio and Switzerland, and a preliminary examination has been made in Wabash, White, Jasper, Howard, Huntington, Miami, Cass, Carroll, Clark, Harrison and Crawford counties.

In the prosecution of the work I have been assisted by Prof. John Collett, Dr. G. M. Levette, Prof. R. B. Warder and Prof. Barnabas C. Hobbs.*

Considerable attention has been given to the analysis of coals and other minerals, in order to be able to make known their true commercial importance and to point out the various uses to which they may be applied.

I take this opportunity, also, to acknowledge my obligations to the following named railroads for favors extended to me in the way of annual passes and for uniform courtesies tending to promote the interests of the Survey :

Indianapolis, Peru & Chicago Railway.
Pittsburg, Cincinnati & St. Louis Railway.
Indianapolis, Cincinnati & Lafayette Railroad.
Jeffersonville, Madison & Indianapolis Railroad.
Indianapolis & Vincennes Railway.
St. Louis, Vandalia, Terre Haute & Indianapolis Railroad.
Indianapolis & St. Louis Railroad.
Cincinnati & Terre Haute Railway.
Evansville & Crawfordsville Railroad.
Louisville, New Albany & Chicago Railroad.
Fort Wayne, Jackson & Saginaw Railroad.
Illinois Central Railroad.

*Prof. Hobbs was employed at the request of the Commissioners of Parke county, and a special appropriation was made in that county to pay for his services, as I was not willing, having already made a general report on this county, to spend further time and money there before visiting counties which had as yet received no attention.

GEOLOGICAL REPORT.

Since the publication of the second volume of my Report on the Geology of Indiana there has been a very great increase in mining operations over the entire area of the coal field, especially along the lines of railroads.

The reputation of the "block coal" for smelting iron ores continues to be fully sustained by its excellent behavior in the blast furnaces that are using it. By making changes at the Brazil Furnace, such as replacing the circle and belly pipes with others of much greater capacity, and putting up gas flues fifty inches in diameter, lined up with fire brick, the yield of this furnace has been increased by four hundred tons per month. She went into blast in October, and during the first thirty days has made one thousand and eight tons of foundry iron especially suited for the manufacture of Bessemer steel. These important improvements were brought about by E. C. Garlick, one of the managers of the furnace.

Mr. Hicks, the intelligent founder, assures me that the furnace now runs with the utmost regularity and he finds no difficulty in making a uniform grade of grey pig.

The Brazil Furnace is sixty-one feet high, fourteen feet across the boshes and is closed at the top. I take pleasure in calling attention to the immense success of this furnace from the fact that it has had a reputation of behaving very badly, and it is to be hoped that it will now not only win an enviable name, but lead the way to still further improvements in furnaces using block coal for fuel. The want of

water which has been experienced at this furnace during the last two seasons of unusual drouth has now been completely obviated by conveying it in cast iron pipes buried beneath the frost line from Otter creek to the furnace.

An account of the new furnace which has just been completed by the Southern Indiana Coal and Iron Manufacturing Company, on the Ohio & Mississippi Railroad near Shoals, in Martin county, Indiana, B. F. Devol, President, and Salem P. Town, Secretary, is given in the following letter received from Cyrus Mendenhall, late of the Kenton Furnace, Newport, Kentucky, and now a member of this new company:

SHOALS, IND., Nov. 12, 1872.

E. T. Cox, *State Geologist*:

Sir—Yours of 31st ult. has been referred to me for a reply. I regret that it has been out of my power to do so earlier.

Our blast furnace is, in size, thirteen feet across the boshes, fifty feet high, with close top like the Kenton Furnace of Newport, and has complete arrangements for heating the boilers and hot blast with the waste gases. The shaft is supported on pillars and has an iron casing lined with fire brick. The furnace is blown with six tuyeres. We have two hot-air stoves of most approved construction. The machinery is all horizontal; steam cylinders twenty-eight inches in diameter and eight feet stroke, with a heavy fly-wheel twenty-two feet in diameter. Blowing cylinder sixty inches diameter with the same stroke as steam cylinder, which works it by direct action. The engine is regarded as a very good one and has a bit of history connected with it. It was captured by the United States authorities from a blockade runner in the Gulf of Mexico, during the late war.

The engine house is of frame, twenty-five by seventy-five feet, and contains, besides the blowing machinery, a separate engine which draws our supply of water from Beaver creek

and distributes the same over the works, including the filling of a tank on top of the elevator that supplies a water-balance for hoisting stock to the top of the tunnel of the furnace. Frame stock house, seventy-two by seventy-five feet, calculated to accommodate a second furnace.

Our furnace is now finished, except attachments of pipes to and about tuyeres, etc., and we have fire in it to-day to warm up, and expect to "blow in" next week. We are receiving iron ores from Iron Mountain and Iron Ridge, Missouri, and from our own mine on Webster's Hill, on the east side of the township, with which we are connected by a side-track from the Ohio & Mississippi Railroad. This bank of ore is over forty-two feet in thickness where it has been opened or uncovered, and the deposit seems to extend around the hill. You are acquainted with the character of the ore and we think it rather improves as we blast into it.

The Sampson Hill coal seam is forty inches thick; we have penetrated it with two entries, about one hundred and twenty yards each, and find the coal of remarkable purity. We are also driving an entry on seam A, at the foot of the hill near the county road, on southeast quarter of section 32, same township; this seam is not so thick as the Sampson Hill, but of very similar character.

A visit from you would be most welcome, and we would take pleasure in giving you such additional information as obtained by recent work in this vicinity.

Yours truly,

CYRUS MENDENHALL.

The rapid increase in the demand for Indiana block coal in Chicago, St. Louis, Cincinnati, Louisville and Indianapolis, without mentioning the numerous cities of less population but large consumers of the fossil fuel, and the consumption on the various railroad lines already constructed, points very clearly to a necessity for more roads from the large manufacturing centers to the coal field, which will not only give additional facilities for opening mines, but, by increasing competition in freights, have the two-fold ten-

dency to lessen its cost as well as to secure a more steady supply. With a view to accomplishing this end, a number of railroad lines have been proposed. On some of them work has been commenced, and others are in part completed.

Of the projected roads that will traverse the coal field, I desire to make brief mention and note their progress toward completion:

The Indiana North & South Railway, E. B. Thomas, President.—The northern division of this road is designed to run from Bloomfield, in Greene county, through Brazil and Carbon, in Clay county, Rockville, in Parke county, and Attica, in Fountain county, to Oxford, in Benton county, on the road running from Lafayette to Chicago via Kankakee, where connection will, for the present, be made with Chicago. This road has been graded from Brazil to within a few miles of Rockville, and is completed and running from Veedersburg, at the crossing of the Indianapolis, Bloomington & Western Railway, to Attica, on the Toledo, Wabash & Western Railway.

Along this completed line, in Fountain county, several shafts have been sunk and adits run to the block coal seam I, and mining operations have been commenced, and villages have sprung into existence like magic. The mines at Kirkland station are new, but the work of driving entries has proceeded so far that they are enabled to deliver four to five car loads of coal per day. Two miles above Veedersburg, a side-track is being laid to Lucas & Co.'s mine, and one and a half miles south of the crossing, Spears & Co. have opened a mine by running an adit on the seam, and are hauling considerable coal to the railroad.

The existence of this seam has also been proved by a bore at Veedersburg.

Joseph E. Young, of the Chicago, Danville & Vincennes Railroad, has organized a branch road from Young's station, on the main line, to run through Covington, in Fountain county, thence south down the valleys of Coal creek and Wabash river to Montezuma, in Parke county, thence up the Raccoon valley and across the table land to Brazil. The

rails have been laid on the division south of Covington to Snoddy's Mill on Coal creek, and, keeping pace with the progress of the road, extensive mining operations have been instituted at that point by Messrs. Phelps & Co. and Messrs. McClelland & Co., and the business of mining is already one of great importance to the community.

At Silver Island, a few miles south of Snoddy's mill, on property owned by Norbourn Thomas, is the Silver Island Mine. This coal is a semi-block, and now finds its way to market by the Wabash & Erie Canal. When it is reached by the railroad it will, on account of its excellence, prove a valuable acquisition to the trade.

The Evansville, Terre Haute & Chicago Railway, running from Terre Haute, Indiana, to Danville, Illinois, has been completed, ballasted and equipped, as predicted in my last report. During the month of March, 1872, they transported fourteen hundred and ten car loads of coal, and have averaged twelve hundred and eleven car loads, of twelve tons each, every month since the completion of the road. This company have arranged for an extension of their road north, from Danville to Gilman, on the Illinois Central Railroad, a distance of forty-eight miles. This extension will be built with easy grades, and laid with steel rails, with an especial view to carrying coals at the lowest possible rates from the Indiana coal field to Chicago. This route, with its connections, will be a short and direct one, and in co-operation with the Illinois Central Railroad, will have excellent facilities for the transportation of freight and passengers from the Wabash Valley to the great Northwest. Coal mines have been opened along the line of this railroad in the southern part of Vermillion county, Indiana, and at the Horse-shoe, on Little Vermillion creek, southwest of Eugene, on the line of the proposed Toledo & St. Louis Railway.

Hough & Co., at Clinton, work their mine by an adit, and elevate the coal to the dump-house by horse power. The seam ranges from four feet eight inches to five feet two inches, and will average five feet in thickness. It burns to

a white ash, without clinker, and makes a satisfactory steam and locomotive fuel.

J. W. Walker, near Clinton, has about one hundred and twenty acres of coal land. His mine is worked by an adit, and the coal elevated to the dump-house by steam power. The present product of this mine is seventy-five tons a day, with a present capacity of one hundred and eighty tons a day; average thickness of seam, five feet six inches. The whole product proves acceptable in the Chicago market for locomotive, steam and household purposes.

Aquilla Nebeker has opened the same seam, one and three quarter miles north of the above named mines, by an adit, but waggons the coal two-thirds of a mile. The seam here is five feet thick; and he is mining thirty-six tons per day. The upper part of the seam is caking coal, while the lower part is laminated, and contains from two to four inches of block coal, as noted by Professor F. H. Bradley, in his Report on Vermillion County, 1869, page 164. It is worthy of note, here, that this seam, which is referable to L in the general section of Indiana coals, is divided into two members by a parting of fire clay. While the upper part is caking, the lower part contains more or less block coal. At the Leatherman, Mill Bank and Firman mines, the entire lower member, twenty to thirty inches thick, is a true block coal, and at the Leatherman mine in particular, where it has been well opened, the walls exhibit the zigzag notches peculiar to block coal mines in Indiana.

At Clinton Locks, Fitch & Co. are putting down a switch to the old mines, once worked on an extensive scale, for shipment by canal. The seam is from five feet six inches to six feet thick. The mine will be in operation by the 1st of January, 1873. They expect to raise fifty tons per day, and have plans for the enlargement of their works this coming summer, which will greatly increase the capacity of the mine.

On the line of the Evansville, Terre Haute & Chicago Railroad, at Hillsdale, in Vermillion county, Burns, Porter & Co. have made a test of the fire clay underlying the coal

which outcrops at that place. Bricks manufactured by hand were placed in the bridge-wall of a puddling furnace along with the justly celebrated Mt. Savage fire brick, and withstood this trying test during a period of more than seven weeks, in a state of perfect preservation ; after which time they were no longer noticed, as the wall appeared to be sound. It may be well to say that the average duration of time which the best known fire brick stand in a similar situation, is nine weeks, and consequently we may fairly expect from this deposit, an article of fire brick, which will successfully compete with the best brands in the market. This clay has the rare and desirable quality of drying without cracking or warping, and with but little shrinkage. A crucial test was made in the hottest fire possible with a common furnace, to glaze or melt it, but without success, which appears to indicate that it is nearly free from alkali and other objectionable substances. These tests, with brick rudely made by hand, are deemed so satisfactory that the proprietors felt justified in beginning operations for manufacturing fire brick, etc., on a large scale. They have visited fire brick factories in the Eastern States and purchased machinery of the latest and best models to be found including a fire clay grinding mill, which has a roller that weighs four thousand pounds, and is capable of reducing a quantity of clay sufficient to make four thousand bricks per day. This mill and other machinery is driven by a twenty-four horse power engine. The company have just fairly commenced manufacturing, and hope to be able to supply a moderate demand during the coming autumn and winter. By next spring they expect to be able to meet the wants of the market.

At the same point, Montgomery & Co., formerly connected with a similar enterprise at Brazil, have erected first class buildings, which are admirably adapted to this branch of manufacture, together with a kiln that has a capacity to burn twenty-five thousand bricks. They have also purchased a set of roller-grinders for the reduction of the clay, to be

driven by steam, and expect soon to be in successful operation. Thorough tests of the clay, which proved eminently satisfactory, have also been made.

H. B. Hammond, President of the Indiana & Illinois Central Railroad, assures me that he will have the Illinois division of this road, from Decatur to Montezuma, on the Wabash river, completed and the cars running by the 1st of January, 1873, and that the Indiana division, through Parke, Hendricks and Marion counties to Indianapolis, will be speedily placed under contract, and completed some time during the coming year.

If the subsidies heretofore pledged to this road in Indiana, are made good, he expects to build it on the surveyed line; but otherwise, the most desirable and least expensive route will be selected; taking, of course, special care to cross the coal field in such a manner as will secure the best locations for coal mining operations. A direct road from the valuable coal field of Vermillion and Parke counties to Indianapolis and the important cities of Illinois, reached by the western division and its connections, must add very greatly to the commercial prosperity of the country. The enterprise has been so long on hand that faith in its completion has been almost lost; yet it is to be hoped, that with the cheering prospect now before us, one more effort will be made by the citizens along the line to have the road located where it will subserve the best interests of the counties through which it is to pass.

The Loganport, Crawfordsville & Southwestern Railway, under the management of John Lee, has been completed since the publication of the last Report, and reaches the coal along the valley of Sand creek, in Parke county. The changes wrought by this railroad through the hitherto quiet and beautiful agricultural district of Sand creek is indeed marvelous. Numerous mines have been opened and are in active operation. The village of Nyesville, four miles from Rockville and filled with a large mining population, usurps the site of a recent field of corn, and the plow has been exchanged for the miner's pick.

A branch road, one and three-quarter miles in length, reaches the Sand Creek Company's mines. Two seams, K and I, are workable on the property of this company, which comprises an area of six hundred acres. These two seams are separated by fifteen to twenty feet of shale and sandstone. The lower seam, 3 ft. 9 in. thick, is good block coal. The upper seam, K, four and a half feet thick, is an excellent quality of caking coal, and is the principal seam mined at this time, as it can be worked by adits at a convenient height above the railroad track to give room for "dump-houses," where the coal is screened and delivered into the cars. The following section exhibits the position of the seams of coal at these mines:

SECTION AT SAND CREEK COAL MINES.				
SPACE.		FT.	IN.	
		8		Soil and Clay.
		26		Drift.
		30		Sandy Shale, with some Flags.
		9		Limestone.
73.6			6	Bituminous Shale.
4.6		4	6	COAL K.
		3		Fire Clay.
18.0		15		Bluish argillaceous Shale.
3.9		3	9	COAL I.
		1		Fire Clay.
11.0		10		Shale and Sandstone.
		110	11	Sand Cr.

This company commenced operations last winter and have now two mines with separate "Head works" arranged in the most approved manner for economizing labor in screening, loading and weighing. The entries and rooms in the mine first opened are now sufficiently extended to permit them to

take out two hundred and forty tons of coal a day, but the delivery, at the time of my visit, only reached one hundred and forty-four tons; on account of a scarcity of miners. The new mine will soon be ready for delivering coal. The demand for this coal for locomotive and general uses is far in advance of the supply, and it has a high reputation in the market. It is a bituminous coal that may be classed as semi-caking from the fact that it agglutinates in burning less than the fatty caking coal of seam L. The color varies from dull black to glossy jet, and the fracture, from cubical to conchoidal, according to the part of the seam from which the specimen is taken.

A proximate analysis of an average specimen from the new mine shows it to be remarkably rich in hydro-carbon.

SAND CREEK COAL.

Specific gravity, 1.296; a cubic foot weighs 81.00 lbs.

Coke,	-	-	50.00	{	Ash, light brown,	-	4.50
				{	Fixed Carbon,	-	45.50
Volatile matter,			50.00	{	Hygroscopic Water,	-	4.50
				{	Gas,	-	45.50
100.00				100.00			

Products obtained by ultimate analysis from 100 parts of coal:

Carbon,	-	-	-	-	-	-	-	76.38
Ash,	-	-	-	-	-	-	-	4.71
Hydrogen,	-	-	-	-	-	-	-	4.71
Oxygen,	-	-	-	-	-	-	-	12.32
Nitrogen,	-	-	-	-	-	-	-	1.88
								100.00

Taking 8080 as the heat unit for the combustion of one part of pure carbon to carbonic acid; and 34,462 as the heat unit for the combustion of one part of hydrogen, which is according to the very accurate determinations of Favet and Silberman, we are enabled, by the aid of the above analysis

of the Sand Creek coal, to calculate its calorific power as compared with the combustion of an equal weight of carbon. These heat units refer to no particular weight, but simply indicate that a grain, or a pound, or a ton will raise the temperature of as many grains, pounds or tons of water from 4° to 5° of Centigrade.

And since the calorific power of hydrogen (34,462) is to the calorific power of carbon (8080), as 1 to 4.265, we have merely to multiply the percentage of available hydrogen by 4.265 and add the product to the percentage of carbon in order to determine its relative calorific power. The total amount of hydrogen found in the coal from the Sand Creek Company's new mine is 4.71 per cent.; of this amount 1.54 per cent. is required to saturate the oxygen (12.32 per cent.), giving 13.86 per cent. of combined water. We have then 3.17 per cent. of available hydrogen, which, multiplied by 4.265, gives 8990 as its relative calorific power compared to the combustion of pure carbon to carbonic acid. The heat unit is found by multiplying the carbon of the fuel by 8080 and the available hydrogen by 34,462. For example: In 100 parts of the sample of coal analyzed from the Sand Creek Company's new mine there are .7638 parts of carbon and .0317 parts of available hydrogen, then $.7638 \text{ C.} \times 8080 + .0317 \text{ H.} \times 34,462 = 7208$ heat units of the coal.

By dividing the heat units (7208) by 100 (the number of degrees, Centigrade, between the freezing and boiling points), we will have 72.08 as the number of pounds of water one pound of the coal will raise from the freezing to the boiling point; and since it requires 5.5 times more heat to convert water into steam than to raise its temperature from 0° to 100° Centigrade, we will find by dividing 72.08 by 5.5 that it will convert 13.10 pounds of water into steam.

Mr. I. Lowthian Bell* considers 11,000 to be the heat unit of the volatile hydrocarbons given off in the combustion of coal. This number I find to be as nearly correct as possible when tested in calculating the calorific power of the Sand

*Chemical phenomena of iron smelting, page 306.

creek from the proximate analysis given above; provided the combined water, 13.86 per cent., is deducted from the total amount of volatile matter as well as the hygroscopic water determined by proximate analysis.

The percentage of solid carbon is .455, which, multiplied by 8080, gives 3676.4 heat units. The total volatile matter is .500, from this must be deducted .045 of hygroscopic water and .138 of combined water, which will leave .317 of hydrocarbons, this multiplied by 11,000 gives 3487 hydrocarbon calories.

The .3487 heat units of hydrocarbon added to the 3676 heat units of the solid carbon, gives 7163 as the heat units of the coal.

The ultimate analysis of an average specimen of coal taken from the old mine belonging to the Sand Creek Coal Company indicates for this coal a still higher calorific power; the elementary constituents in 100 parts are :

Ash, white,	-	-	-	-	-	-	3.19
Carbon,	-	-	-	-	-	-	77.03
Hydrogen,	-	-	-	-	-	-	5.60
Oxygen,	-	-	-	-	-	-	12.64
Nitrogen,	-	-	-	-	-	-	1.54
							100.00

It gave less ash and a larger percentage of carbon and hydrogen.

Calculated as before :

Carbon,	-	-	-	.7703	×	8080	=	6224
Available hydrogen,	-	-	-	.0402	×	34462	=	1385
								Gives heat units=7609

A pound of coal will raise 76.09 pounds of water from the freezing to the boiling point.

The proximate analysis of this coal was not made, consequently no comparison can be given of the two modes of calculation.

At the end of this Report a table will be found showing the calorific power of all the coals which the time allotted to chemical work has enabled us to make.

The Sand creek coal has a deservedly high reputation for steam and household use, and commands in the Chicago and Indianapolis markets as good a price as the block coal.

The other mines on Sand creek which are working this seam are: Parke Coal Company, Campbell's mine, and Kyle's mine.

Coal K is found over a large area of Parke county; it is the coal mined by Beard on section 25, town 15, range 6 and by Nevin on section 31, town 15, range 6 in the south part of the county.

The proximate analysis of Beard's coal, given below, shows it to be fully equal to the Sand Creek coal:

BEARD'S COAL.

Specific gravity, 1.191; one cubic foot weighs 74.43.

Coke, - - 49.50	{	Ash, white, - - -	1.00
		Fixed carbon, - - -	48.50
Volatile matter, 50.50	{	Water, - - - -	8.00
		Gas, - - - -	42.50

Coke lamellar, brilliant, not swollen.

The details of the geology of this county will be found in the able report of Prof. Barnabas C. Hobbs.

The Indianapolis & St. Louis Railroad Company have surveyed a route for a branch road, which leaves the main line a short distance east of Carbon, in Clay county, and passing half a mile north of that town, continues westward and returns to the main track at Lodi, about eight miles from the starting point.

A shaft has been sunk and quite a number of mining enterprises have already been started along this proposed road which traverses a good district for coal.

The enterprising managers of the St. Louis, Vandalia, Terre Haute & Indianapolis Railroad are pushing their branches still farther south, and some of the heaviest mining

operations in the county are now carried on in this part of the block coal field. This road, with its fine equipment of cars and numerous branches that traverse the block coal field, is hauling nearly all the coal that is at present mined in this county for market.

A portion of the western division of the proposed railroad from Cincinnati to Terre Haute has been finished, and trains are running from Terre Haute to Middlebury, in Clay county. Mines have been commenced along the road to work the seams of caking coal over which it passes. The present terminus does not reach quite far enough east to strike the zone of block coal.

An organization has been recently formed, which comprises some of the leading business men of Indianapolis, to build a railroad to the block coal field in the southeastern part of Clay and western part of Owen counties, to be known as the Indianapolis Block Coal & Western Railway. The termini are Indianapolis and a point at or near Merom, on the Wabash river, in Sullivan county, Indiana.

If this road is built, it will afford facilities for extensive mining and manufacturing operations along the line, and prove of incalculable benefit to the country through which it passes, as well as to the city of Indianapolis.

A number of railroads are projected to run across the coal field in the southern part of the State.

The New Albany & St. Louis Air Line Railway has a portion of the track completed and the cars running over it.

I am also informed that the greater part of the road-bed in this State is finished ready for the iron, and that through the untiring energy of the President, Mr. Bradley, and the Secretary, Mr. Lyman, work is pushed forward with great rapidity all along the line.

Coal mines are already opened, and their numbers will rapidly increase along the road when it is completed to the great coal markets that it is designed to reach.

The Cincinnati & Rockport Railroad, which is to run from Rockport, on the Ohio river, in Spencer county, to Mitchell, in Lawrence county, Ind., and from thence, by connections



with the Ohio & Mississippi Railroad, to Cincinnati, Ohio, is being built. The greater part of the grading has been finished in Spencer county, and it is expected that the road-bed will soon be ready for the iron as far north as Jasper, in Dubois county.

This road runs through the block coal field in the north part of Spencer and in Dubois counties, and will open up facilities for the establishment of blast furnaces in this part of the measures, as iron ores may be brought to Rockport by boats on the Ohio river.

A branch of the Cincinnati & Rockport Railroad is projected to run from Mitchell across the coal fields in Dubois, Pike, Gibson and Posey counties, and terminate at Mt. Vernon on the Ohio river, in the latter county.

The Evansville & Sandusky Railroad is projected to run from Evansville, in Vanderburg county, through the coal field in Warrick county, and a portion of Spencer and Dubois counties; thence to Seymour, at the crossing of the Jeffersonville, Madison & Indianapolis Railroad and the Ohio & Mississippi Railroad. The road-bed, I am informed, has been completed on this line from Evansville to Booneville, in Warrick county, and there is reason to believe that the road will be speedily finished to Seymour. It connects Evansville with the block coal field by the most direct route, and will insure to her flourishing manufacturers a supply of excellent fuel.

Evansville is favorably situated for obtaining iron ore by water transportation, at very low rates, from Missouri and the large deposits in the region bordering the Cumberland river in Kentucky. This, together with the ready access which the above road will secure to the block coal, gives them facilities for manufacturing iron that are not surpassed by any location in the State. The large rail rolling mill which is being built this year will prove but the beginning of her success in that direction, and open the road for the erection of blast furnaces.

The Indiana Mineral Railway is projected to run from a point on the Ohio river at or near the mouth of Anderson

creek, northward through Jasper, in Dubois county, to Black Oak Station, on the Ohio & Mississippi Railroad, in Daviess county, thence continuing north to Bloomfield, in Greene county, where it will connect with the proposed Indiana North & South Railway.

Mr. John Alexander, of Philadelphia, the President of this road, is making every possible exertion to have it built.

It is the intention of the officers of this road to locate it near the center of the block coal zone, with a view of making the coal available for iron manufactures that are to be established at the terminus on the Ohio river. I am not aware that any grading has yet been done on this road.

Before dismissing the subject of railroads, which so materially aid in the development of the country, it may be well in this connection to make a few remarks in reference to the Wabash & Erie Canal. The lower part of this canal, from Montezuma, in Parke county, to Evansville, on the Ohio river, which is now without water and abandoned, runs through the very heart of the coal measures as well as one of the finest agricultural districts in the State. There is also in places along this portion of the canal large quantities of excellent timber.

If, in view of these facts, the owners of the canal would go to work and put it into good order it would eventually be one of the best investments in the State. When first made, the country through which it passed was for a great part of the distance almost a wilderness with but little commerce. It now teems with an agricultural, manufacturing and mining population that will furnish all the commerce that can be desired. Blast furnaces will be erected along its banks and the supply of ores to feed their rapacious stomachs can be brought by water transit from the large deposits of Missouri and the Cumberland river districts; as also the Lake Superior ores by its northern division. The valuable coal which may be mined along its banks and loaded direct from the shafts into boats will find its way to ready markets both north and south. Indeed, there is not a more favorable location to be found for a canal, and why the very part

which is sure to be remunerative has been abandoned and let go to ruin is difficult to understand. The fact of railroads running by its side for a part of the way is not a good and sufficient excuse for its abandonment. There is now, and will be, business enough for all, and the policy which has been pursued must be placed to the account of bad management and want of foresight on the part of the directors.

Since the publication of my Report on Daviess county, the Buckeye Cannel Coal Company have sunk a shaft at Black Oak Station, on the Ohio & Mississippi Railroad, which, at a depth of eighty feet, reached a seam of coal I, four feet six inches thick. The upper part of this seam, two feet six inches, is a hard, compact cannel coal, and the lower part of the same, two feet, is a rich caking coal. The two qualities of coal are not separated, as is usual, by shale or fire clay, but are so firmly united that fragments of the under part are often found attached to the cannel coal.

The following is a section of the strata passed through by their shaft :

BLACK OAK STATION.				
SPACE.		Ft.	In.	
39.		18		Soil and Clay.
		15		Quick Sand.*
		6		Gray Shale.
3.		3		BLOCK COAL K.
16.		5		Hard Fire Clay.
		4		Sandstone.
		7		Gray Shales.
1.4		1	4	BLOCK COAL.
15.		1		Fire Clay.
		4		Sandstone.
		10		Black Slate.
4.6		4	6	COAL I. { CANNEL, 2 ft. 6 in. CAKING, 2 ft. 0 in.
2.		2		Fire Clay.
TOTAL.		80	10	

*A stream of water was encountered in this sand, which gave them great trouble, and materially increased the cost of sinking the shaft. The flow of water was estimated at 1,000 barrels in 24 hours.

The Buckeye Cannel Coal Company have their mine in full operation and the coal meets with general favor. While the lower part brings the usual price of caking coal, the upper part, which is cannal, commands two to three cents

more per bushel and has a ready sale. The top seam of coal K, of this shaft is block, but here the roof is not strong enough to admit of its being worked, though on an adjoining property it has a good roof and is worked by an adit.

An exhaustive chemical analysis has been made of both the cannel and caking coal mined by the Buckeye Cannel Coal Company and the results are here given:

Cannel coal, proximate analysis:

Specific gravity, 1.229; one cubic foot weighs 76.87 lbs.

Coke,	-	-	48.00	{	Ash, white,	-	-	6.00
				{	Fixed carbon,	-	-	42.00
Volatile matter,	52.00	{	Hygroscopic Water,	-	-	-	-	3.50
		{	Gas,	-	-	-	-	48.50

Coke laminated, not swollen, lustreless.

Ultimate analysis of the same:

Carbon,	-	-	-	-	-	-	-	71.10
Ash	-	-	-	-	-	-	-	7.65
Hydrogen,	-	-	-	-	-	-	-	6.06
Nitrogen,	-	-	-	-	-	-	-	1.45
Oxygen,	-	-	-	-	-	-	-	12.74
Sulphur,	-	-	-	-	-	-	-	1.00

100.00

The relative calorific power is 9029; carbon being 8080, thus:

Available hydrogen,	-	.045	$\times 4.265$	$= 1919$
Carbon,	-	.7110	$+ 1919$	$= 9029$

The heat units of the coal are 7294, thus:

.7110 carbon $\times$ 8080 heat units $= 5744$ carbon heat units.

.045 available hydrogen $\times 34462 = 1550$ hydrogen heat units.

1550 hydrogen heat units $+ 5744$ carbon heat units $= 7294$ coal heat units.

Expressed in a manner that will be more generally understood, it may be stated that the calculated or theoretical calorific power of this coal indicates that one pound of coal will raise the temperature of 72.94 pounds of water from the

freezing to the boiling point, or one pound of coal will convert into vapor 13.26 pounds of boiling water.

The heat units calculated from the proximate analyses are in this instance somewhat greater than is shown by the ultimate analyses, which may, in part, be owing to the fact that the analyses were made from different specimens, and that while one shows only six per cent. of ash, the sample taken for ultimate analysis gave 7.65 per cent.

Tested for gas, one pound of this cannel coal gave 4.86 cubic feet which had an illuminating power equal to 25.2 sperm candles. In practice the yield will be much greater.

For the purpose of comparison, a sample of Youghiogeny coal obtained from the Indianapolis Gas Works, and here considered the best gas coal to be had in the Pennsylvania field, was tested in the same manner, and the yield of illuminating gas was 4.05 cubic feet to the pound of coal, with an illuminating power of seventeen candles. In practice, at the Gas Works, the Youghiogeny coal yields 4.34 cubic feet per pound. The difference between the laboratory result, 4.5 cubic feet, and the practical yield of gas in the gas works, 4.34 cubic feet, furnishes a data by which to calculate the quantity of gas which may be obtained from the Daviess county cannel coal by distillation under similar conditions.

The ratio of the two quantities is as 1. to 1.07; therefore we have merely to multiply the number of cubic feet, 4.68, obtained in the laboratory, by 1.07 to find the number of cubic feet which the cannel coal will yield at the gas works, thus:

$$4.68 \times 1.07 = 5.2 \text{ cubic feet.}$$

In practice then the cannel coal will furnish 5.2 cubic feet of gas to the pound of coal, or 10400 cubic feet to the ton of 2000 pounds, and the Pittsburg coal 4.34 cubic feet to the pound, or 8680 cubic feet to the ton. The ratio of the two quantities is as 1 to 1.2.

It is not only the increased quantity of gas which the cannel coal yields that recommends it to the favorable con-

sideration of the gas companies, but it likewise gives a gas of very high illuminating power.

The illuminating power of a gas is ascertained by comparing the light which it will give in burning five cubic feet per hour in a standard argand burner, with the light given by a standard sperm candle, six to the pound and burning one hundred and twenty grains of sperm per hour. Tested in this manner the gas from Pittsburg coal has an illuminating power of seventeen standard sperm candles, and that from the Daviess county cannel coal 25.2 candles or as 1 to 1.5.

The value of gas in grains of sperm consumed is found by multiplying the candle power by 120, the number of grains of sperm consumed, and dividing the product by five, the number of feet of gas burned.

$$\frac{25.2 \times 120}{5} = 605.$$

The value, then, of one cubic foot of gas from the cannel coal is equal to the value of 605 grains of sperm.

Calculated for the Pittsburg coal we have:

$$\frac{17 \times 120}{5} = 408 \text{ grains.}$$

One cubic foot of this gas is equal in value to 408 grains of sperm. The relative value of the two gases in sperm, the Pittsburgh taken as one, is 1 to 1.5.

To offset the deficiency in quantity and illuminating power of the gas from the Pittsburg coal as compared with that from the Daviess county cannel coal, we must bear in mind that while the coke from the former coal is abundant and of excellent quality, and the large surplus over what is required for heating the retorts finds a ready sale in the market as a fuel, the coke from the cannel coal is small in quantity and comparatively inefficient for fuel.

The comparisons given below of the relative values of the two cokes are made from the laboratory experiments;

as the results obtained at the gas works are variable from the fact that coke gains from twenty to twenty-five per cent. in weight by being wet.

One hundred parts of Pittsburg coal distilled for gas, gave:

Coke,	-	-	70	} = 67 per cent. of solid carbon.
Ash,	-	-	3	

One hundred parts of cannel coal gave:

Coke,	-	-	52.8	} = 39.3 per cent. of solid carbon.
Ash,	-	-	18.5	

Rating Pittsburg coal as 1, the value of the respective coles is as 1. to 0.587. We may consider, therefore, that the coke from the former is worth twice as much as that from the latter, for heating purposes.

A table will be given, further along, showing the relative value of all the coals which have been tested for gas, but I desire, in this place, to make special note of the analyses which have been made to determine the value of the coal from seam L for gas purposes.

The coal from Washington, in Daviess county, has not been tested in the laboratory; but a practical test was made at the Indianapolis Gas Works, and the yield was 4.16 cubic feet per pound. Being absent from the city at the time this test was made, I had no opportunity of determining its illuminating power; but Mr. Stacy, the intelligent and obliging superintendent of the works, to whom I am indebted for a multitude of favors,* informs me that it was

*The Indianapolis Gas Light & Coke Company, having remodeled and greatly enlarged their buildings, have now the most complete gas works in the West. Everything is being made new, and no expense has been spared to procure machinery and apparatus of the most approved character. They are also putting up and have nearly completed a miniature gas works for testing coals for gas. Twenty pounds, or the one hundredth part of a ton, is the capacity of the retort, and this quantity will be ample to enable them to determine the amount and illuminating power of the gas, and, in fact, the value of all the constituents of the coal. Such an apparatus should be purchased by the State for the use of the survey, as I do not feel at liberty to trespass upon the uniform courtesy which the Gas Company and their agents have always shown to me when seeking information which, in some instances, it might not be prudent to give if governed by pecuniary interests.

nearly equal to the Pittsburg, and the yield of coke was very fair as to quantity and quality.

In the Pioneer shaft at Curryville in Sullivan county, Indiana, which is owned by Smith, Beswick & Co., there are two seams of caking coal, L and K, as given in the section of this shaft by Prof. John Collett.*

The space between the two is forty-seven feet. The upper seam, L, is 4 ft. 6 in. thick and the lower seam, K, is 5 ft. 2 in. thick.

Tested for illuminating gas, this lower seam gave, calculated for one pound of coal, first trial:

Gas,	-	-	-	-	-	3.68	cubic feet
Coke,	-	-	-	-	-	.575	pounds.
Carbonic acid and Sulphur,	-	-	-	-	-	.015	"
Water,	-	-	-	-	-	.025	"
Tar and ammoniacal liquor,	-	-	-	-	-	.070	"

Second trial of same coal gave:

Gas,	-	-	-	-	-	3.61	cubic feet.
Coke,	-	-	-	-	-	.625	lbs.
Tar and ammoniacal liquor,	-	-	-	-	-	.075	lbs.
Water,	-	-	-	-	-	.025	"
Carbonic acid and Sulphur,	-	-	-	-	-	.010	"

The average yield of gas by the above analysis is 3.65 cubic feet per pound of coal, which, multiplied by 1.07, the ratio between the laboratory yield and the quantity obtained by distillation at the gas-works gives:

$$3.65 \times 1.07 = 3.90.$$

The gas value of this coal may then be fairly stated at 3.90 cubic feet to the pound. Mr. Stacy, Superintendent of the Indianapolis Gas-works, made a trial of the same coal from Sullivan county, probably from this seam, and he thought the yield of gas was about four cubic feet to the pound of coal.

The illuminating power is equal to fifteen candles, which

*See Geological Rep. 1870, pp. 212-213.

is two less than that of the Youghiogheny coal. The average yield of coke is sixty-five per cent. Ash in the coke 4.46 per cent., leaving 60.54 per cent. of solid carbon.

The value of the Standard shaft coal, for gas, compared with the Youghiogheny, is:

Youghiogheny,	-	-	-	-	100	} Ratio of quantity.
Standard,	-	-	-	-	90	

As compared for illuminating power:

Youghiogheny,	-	-	-	-	100	} Ratio of quality.
Standard,	-	-	-	-	88	

Value of coke:

Youghiogheny,	-	-	-	-	-	100
Standard,	-	-	-	-	-	90

An exhaustive analysis has been made of another coal from Sullivan county, belonging to Henry K. Wilson:

Specific gravity, 1.228; weight of one cubic foot, 76.75 lbs.

Coke,	-	-	52.40	{	Ash, white,	-	-	-	.80
					Solid carbon,	-	-	-	51.60
Volatile Matter,	47.60	{			Water,	-	-	-	2.35
					Gas,	-	-	-	45.25

Coke puffed, brilliant and porous.

Ultimate Analysis: *

Ash, red,	-	-	-	-	-	1.66
Carbon,	-	-	-	-	-	4.09
Nitrogen,	-	-	-	-	-	1.80
Oxygen,	-	-	-	-	-	11.45
Sulphur,	-	-	-	-	-	1.00

100.00

Calculated for calorific power:

Carbon $.8409 \times 8080 = 6794.4$ carbon heat units.

Available } $.0351 \times 34462 = 1209.6$ hydrogen heat units.
hydrogen }

$6794.4 + 1209.6 = 8004$. total heat units.

The calorific power is 8004 heat units.

*Made from another specimen of the coal.

One pound of coal will raise 80 pounds of water from the freezing to the boiling point, or convert 14.54 pounds of boiling water into vapour.

The calorific power calculated from the results obtained by the proximate analysis is a little less:

Solid carbon $.516 \times 8080 = 4169$ carbon heat units.

Hydrocarbons after de-
ducting hygroscopic and } $3237 \times 11000 = 3560$ heat units.
combined water.

$4169 + 3560 = 7729$ total heat units.

Tested by either mode of calculation the calorific power of this coal is very high.

Distilled for gas, one pound of coal gave:

Pure illuminating gas,	-	-	3.95	cubic feet.
Coke,	-	-	.675	pounds.
Ash,	-	-	.012	"
Ammoniacal liquor,	-	-	.05	"
Candle power,	-	-	15.	

Comparative yield of gas:

Youghiogheny,	-	-	-	-	100.
Wilson,	-	-	-	-	98.

Illuminating power:

Youghiogheny,	-	-	-	-	100.
Wilson,	-	-	-	-	88.

Value of coke:

Youghiogheny,	-	-	-	-	100.
Wilson,	-	-	-	-	97.

It will be apparent from the above that the Wilson coal, for gas, approaches very closely to the best Youghiogheny gas coal.

In order that our Western coals may be more fully appreciated and their true value for gas understood by the gas companies, I will give a few examples in the way of drawing a comparison between the value of the English,

the Indiana and the Youghiogheny gas coals, estimating the latter at 100.

The English coal here cited is the average of forty-eight samples of caking coals used at various gas works.

	YOUGHIOGHENY.	ENGLISH.	WILSON'S INDIANA.
Yield of gas, - - -	100	106	98
Illuminating power, -	100	74	88
Value of coke, - - -	100	95	97

Specimens of peat from St. Joseph county, Indiana, cut from the bog in cubes, pressed and thoroughly air dried, were obtained from Rev. W. Corby, of Notre Dame College, where it is largely used as fuel, have also been tested to determine its commercial value as fuel, compared with wood; and for gas, compared with Youghiogheny coal.

The proximate analysis gave:

Coke,	-	-	36.00	{	Ash, dirty yellow,	-	9.50
				{	Solid carbon,	-	26.50
Volatile Matter,			64.00	{	Water,	-	8.50
				{	Gas,	-	55.50

Calculated for calorific power:

Solid carbon $2650 \times 8080 = 2141$ carbon heat units.

Hydrocarbon $5550 - \text{combined water } 3646 = \text{hydrocarbon } 1905 \times 11000 = 2095$ heat units.

$\frac{1}{2}$ $2141 + 2095 = 4236$ total heat units for the peat. This, in calorific effect, will raise 42.36 pounds of water from the freezing to the boiling point, or convert 7.7 pounds of boiling water into vapor.

Air dried beech wood, as used for fuel, contains in 100 parts*:

Carbon, - - - - -	39.10
Hydrogen, - - - - -	4.90
Oxygen, - - - - -	36.00
Water and Ash, - - - - -	20.00

*See Wagner's Chemical Technology, page 704.

Calculated for calorific power :

Carbon, - $.3910 \times 8080 = 3159$ carbon heat units.
 Available hydrogen, $.004 \times 11000 = 44$ hydrogen heat units.
 $3159 + 44 = 3203$ total heat units.

This will raise 32.03 pounds of water from the freezing to the boiling point and convert 5.8 pounds of boiling water into vapor.

The relative evaporating value of the St. Joseph county peat, well dried, and air-dried beech wood may be stated thus :

100 pounds beech wood will evaporate 5.8 pounds water.

100 pounds peat will evaporate 7.7 pounds water.

Ratio of value :

Wood,	-	-	-	-	-	-	100.
Peat,	-	-	-	-	-	-	133.

That is, the peat has, theoretically, about one-third more evaporating power than the wood.

An example of peat given by Wagner* has 4033 heat units. The evaporative power is 7.3 pounds of water, which is nearly the same as obtained from the St. Joseph peat.

A numbers of examples from the same authority—Wagner—are here given for the sake of comparison. They are according to Brix's investigations.

			WATER. Per cent.	UNDRIED. Per cent.	DRIED. Per cent.
Fir wood,	-	-	16.1	4.13	5.11
Elm,	-	-	14.7	3.84	4.67
Birch,	-	-	12.3	3.72	4.39
Oak,	-	-	18.7	3.54	4.60
Red beech,	-	-	22.2	3.39	4.63
White beech,	-	-	12.5	3.62	4.28

That is to say, one pound of fir wood, containing 16.1 per cent. of water will evaporate 4.13 pounds of water.

The evaporating power of wood is only half that of caking coal, and according to the above results, it is also less effective than the Notre Dame compressed peat.

*Wagner's Chemical Technology, page 701.

Peat is the carbonaceous product resulting from the decomposition of plants which grow in shallow stagnant water. The plants from which it is chiefly derived belong to the family of mosses. The most abundant peat-forming plant is the sphagnum, which sends out new shoots and continues to grow at the surface of the water, while the older parts are undergoing the transformation into peat.

The cost of cutting and preparing peat for market, in this country where labor commands such high wages, is very great; but when the better kinds are properly pressed and dried, it makes a very desirable fuel, and the time is not far distant when it will be brought into more general use in the northern part of the State, where there is no stone coal, and wood is becoming scarce.

The results obtained, and given above, for the calorific power of fuel, are based upon the complete conversion of its combustible constituents into carbonic acid and water. As this, however, is seldom, if ever, accomplished in practice, and there is besides, a very great loss by radiation and from the formation of soot, cinder, etc., the calorific power obtained from fuel, in its practical application, is seldom more, and in many instances very much less than one-half of its theoretical value. The heat generated by the combustion of carbon to carbonic acid is 8080, while the heat generated by the combustion of twice the weight of carbon to carbonic oxide is 4946, showing a loss of 3134 heat units.*

The value of fuel depends very much on the amount of volatilizable substances which it contains, and coals which have a large amount of hydro-carbons burn with a large flame, and are considered the best for generating steam, while the less gaseous coals are preferred for iron smelting.

The examples given by I. Lowthian Bell,† to show the relative value of coke and raw coal for smelting iron in blast furnaces, are defective. The estimate for the heat units for the volatile matter of the coal, is too great. A deduc-

*Watt's Dictionary of Chemistry, Fuel.

†Chemical Phenomena of the Blast Furnace, pp. 305, 306.

tion of at least four-tenths should be made for the hygroscopic and combined water of the coal.

On the other hand, either the raw coal, of the Scotch furnaces cited, was of a character unsuited for the business, or the furnaces and the blast were not arranged to secure a favorable combustion of the coal.

A much better result is obtained from the use of raw block-coal in Clay county, where only 4250 pounds of coal are required to make a ton of iron, and I am fully of the opinion that with properly constructed furnaces this quantity may be materially reduced.

The elementary analyses of five block-coals, used for smelting iron, are here subjoined:

	Ash.	Carbon.	Hydrogen.	Nitrogen.	Oxygen	Sulphur.
Garlick & Collins' Brazil Fur'ce, No. 1	3.88	76.81	4.13	1.78	12.90	.50
" " No. 2	1.07	82.70	4.77	1.62	9.39	.45
Star Mine, Planet Furnace, No. 1.....	2.74	80.74	5.61	1.67	8.60	.73
" " No. 2.....	2.74	81.60	4.39	1.67	8.87	.73
Clay Coal Company's Mine.....	1.68	84.68	4.10	1.35	7.69	.50

The average of the two specimens analyzed from Garlick & Collin's mine will give:

Carbon, $.7975 \times 8080 = 6444$ carbon heat units.

Hydrogen, $.0306 \times 34462 = 1054$ hydrogen heat units.

$6444 + 1054 = 6498$ total coal heat units.

The average of the two specimens analyzed from the Star Mine will give:

Carbon, $.8120 \times 8080 = 6560$ carbon heat units.

Hydrogen, $.05 \times 34462 = 1723$ hydrogen heat units.

$6560 + 1723 = 8283$ total coal heat units.

The practical evaporative effect of a coal may be taken as equal to two-thirds of that which has been calculated from its chemical composition.

The following coals collected by Prof. John Collett, from Dubois and Pike counties, have been proximately analyzed and the results are given below, for an account of these coal seams the reader is referred to Prof. Collett's report in this volume :

Northeast part of Dubois county, on Davidson creek, near Ludlow, is Burnham's coal A, one foot thick ; color, bright ; fracture, conchoidal and splintery ; composition in 100 parts :

BURNHAM'S COAL A.

Specific gravity, 1.306 ; one cubic foot will weigh 81.62 pounds.

Coke,	-	-	56.50	{	Ash, white,	-	-	3.50
				{	Fixed carbon,	-	-	53.50
Volatile matter,			43.50	{	Water,	-	-	4.50
				{	Gas,	-	-	39.00
100.00								
				100.00				

Coke lamellar, brilliant, not puffed.

ELKIN'S COAL A.

Section 21, township 1 north, range 3 ; seam 11 inches thick. Same seam as Burnham's, in the same vicinity, and is similar in appearance.

Specific gravity, 1.295 ; one cubic foot will weigh 80.93 pounds.

Coke,	-	-	54.50	{	Ash, brown,	-	-	4.00
				{	Fixed carbon,	-	-	50.50
Volatile matter,			45.50	{	Water,	-	-	6.50
				{	Gas,	-	-	39.00
100.00								
				100.00				

Coke lamine, dull, not puffed.

HARBISON'S COAL A,

Is situated on the bank of White river, in section 26, township 1 north, range 5, about three miles east of Portersville ;

the seam is 18 inches thick, the upper four inches of which is cannel, and the lower part semi-block. The analysis given below is of the cannel part of the seam :

Specific gravity, 1.198 ; one cubic foot will weigh 74.87 pounds.

Coke,	-	-	33.50	{	Ash, pink,	-	-	-	10.00
				{	Fixed carbon,	-	-	-	23.50
Volatile matter,			66.50	{	Water,	-	-	-	6.00
				{	Gas,	-	-	-	60.50
100.00									
				100.00					

Middle part, bright, slaty cannel, 2 ft. 4 in. thick. Specific gravity, 1.264; one cubic foot will weigh 79. lbs.

Coke,	-	-	52.50	{	Ash, white,	-	-	3.00
				{	Fixed carbon,	-	-	49.50
Volatile matter,			47.50	{	Water,	-	-	7.00
				{	Gas,	-	-	40.50
100.00								
				100.00				

Coke, puffed, vitreous, lamellar.

Bottom part, laminated block coal, eight inches thick. Specific gravity, 1.271; one cubic foot will weigh 79.43 lbs.

Coke,	-	-	53.50	{	Ash, white,	-	-	2.00
				{	Fixed carbon,	-	-	51.50
Volatile matter,			46.50	{	Water,	-	-	6.50
				{	Gas,	-	-	40.00
100.00								
				100.00				

Coke slightly puffed, vitreous, laminate.

This coal is well adapted for general use, and may be used in the manufacture of iron.

KESLER'S COAL A.

Near St. Anthony, section 34, township 2 south, range 4, on the New Albany & St. Louis Air Line Railway, 3 ft. 6 in. to 4 ft. thick where opened. The general character of the seam at this place is a semi-block; analyses were made from the upper, middle, and lower parts of the seam.

Upper part, slaty coal, 3 inches. Specific gravity, 1.333; one cubic foot will weigh 83.31 lbs.

Coke,	-	-	51.50	{	Ash, blue,	-	-	11.50
				{	Fixed carbon,	-	-	40.00
Volatile matter,			48.50	{	Water,	-	-	7.00
				{	Gas,	-	-	41.50
100.00								
				100.00				

Coke puffed, amorphous, vitreous.

Middle part, block, approaching cannel, 2 feet; specific gravity, 1.268; one cubic foot will weigh 79.25 lbs.

Coke,	-	-	49.00	{	Ash, gray,	-	-	-	8.50
				{	Fixed carbon,	-	-	-	40.50
Volatile matter,	51.00	{	Water,	-	-	-	-	6.00	
		{	Gas,	-	-	-	-	45.00	
			100.00					100.00	

Specific gravity, 1.305 ; one cubic foot will weigh 81.56 pounds.

Coke,	-	-	53.50	{	Ash, fawn,	-	-	-	5.50
				{	Fixed carbon,	-	-	-	48.00
Volatile matter,			46.50	{	Water,	-	-	-	5.50
				{	Gas,	-	-	-	41.00
				100.00					100.00

Coke much puffed, vitreous, amorphous.

This coal is near the line of the Rockport and Cincinnati Railway.

H. B. KATHMAN'S COAL A.

Two miles southeast of Ferdinand, on section 3, township 4 south, range 4, in the edge of Spencer county ; one foot ten inches thick ; worked by stripping ; caking coal.

Upper part, laminate semi-block.

Specific gravity, 1.250 ; one cubic foot weighs 78.12 lbs.

Coke,	-	-	47.50	{	Ash, white,	-	-	-	2.00
				{	Fixed carbon,	-	-	-	45.50
Volatile matter,			52.50	{	Water,	-	-	-	4.00
				{	Gas,	-	-	-	48.50
				100.00					100.00

Coke slightly swollen, lustreless, laminate.

Lower part, cubical caking coal.

Specific gravity, 1.251 ; one cubic foot weighs 78.19 lbs.

Coke,	-	-	50.00	{	Ash, white,	-	-	-	2.50
				{	Fixed carbon,	-	-	-	47.50
Volatile mater,			50.00	{	Water,	-	-	-	5.00
				{	Gas,	-	-	-	45.00
				100.00					100.00

Coke swollen, vitreous, laminate.

BRIDENBAUGH'S COAL K.

On section 27, township 1 north, range 5, two feet eight inches thick ; semi-caking coal ; upper part laminated ; lower part cubical with calcite in the cleavage partings.

Upper part:

Specific gravity, 1.273; one cubic foot weighs 79.56 lbs.

Coke, - - -	56.50	{	Ash, red, - - -	4.00
		{	Fixed carbon, - - -	52.50
Volatile matter, 43.50		{	Water, - - -	6.50
		{	Gas, - - -	37.00
	100.00			100.00

Coke laminate, dull, not puffed.

Middle part:

Specific gravity, 1.285; one cubic foot weighs 79.06 lbs.

Coke, - - -	55.00	{	Ash, light red, - - -	3.50
		{	Fixed carbon, - - -	51.50
Volatile matter, 45.00		{	Water, - - -	4.50
		{	Gas, - - -	40.50
	100.00			100.00

Coke dull, laminate.

Lower part:

Specific gravity, 1.246; one cubic foot weighs 77.87 lbs.

Coke, - - -	56.00	{	Ash, red, - - -	3.50
		{	Fixed carbon, - - -	52.50
Volatile matter, 44.00		{	Water, - - -	5.00
		{	Gas, - - -	39.00
	100.00			100.00

Coke laminate, dull, slightly puffed.

RUDOLPH'S COAL K.

On section 20, township 1 north, range 5, one mile west of Portersville, seam three feet thick. Specific gravity, 1.361; one cubic foot weighs 78.81 lbs.

Coke, - - -	52.50	{	Ash, red, - - -	4.00
		{	Fixed carbon, - - -	48.50
Volatile matter, 47.50		{	Water, - - -	5.50
		{	Gas, - - -	42.00
	100.00			100.00

Coke laminate, lustreless, not swollen.

Only the upper part of this seam has been analysed, for want of time. It is a bright, black caking coal, excellent for steam and blacksmiths' use.

JOE STEIN'S COAL.

On section 53, township 1 south, range 4, one and a half miles south of the line of the Evansville & Sandusky Railway; seam reported two feet thick.

Specific gravity, 1.260; one cubic foot weighs 78.75 lbs.

Coke, - -	52.00	{	Ash, brown, - -	3.50
			Fixed carbon, - -	48.50
Volatile matter, 48.00		{	Water, - - -	4.50
			Gas, - - -	43.50
	100.00			100.00

Coke swollen, laminate, lustreless.

MICHAEL WILSON'S COAL K.

One quarter of a mile north of Jasper; semi-block and block; three feet thick; color, dull black. The middle part of the seam is excellent coal.

Specific gravity, 1.416; one cubic foot weighs 88.50 lbs.

Coke, - -	55.50	{	Ash, white, - -	2.50
			Fixed carbon, - -	53.00
Volatile matter, 44.50		{	Water, - - -	4.00
			Gas, - - -	40.50
	100.00			100.00

Coke laminate, not swollen, vitreous.

The following analysis was made of another specimen from the same mine:

Specific gravity, 1.286; one cubic foot will weigh 80.37 pounds.

Coke, - -	49.50	{	Ash, red, - - -	5.00
			Fixed carbon, - -	44.50
Volatile matter, 50.50		{	Water, - - -	6.00
			Gas, - - -	44.50
	100.00			100.00

Coke brilliant, laminate, slightly swollen.

ADAM SMITH'S COAL K?

Three and a half miles south of Jasper, on section 11, township 2 south, range 5; the seam is from 3 ft. 6 in. to 4 feet thick.

Upper part, bright caking coal:

Specific gravity, 1.256; one cubic foot weighs 78.50 lbs.

Coke,	-	-	47.00	{	Ash, white,	-	-	-	3.50
				{	Fixed carbon,	-	-	-	43.50
Volatile matter,			53.00	{	Water,	-	-	-	7.00
				{	Gas,	-	-	-	46.00
100.00									

Specific gravity, 1.275; one cubic foot weighs 79.68 lbs.				
Coke,	-	-	52.50	{
				{ Ash, white, - - - 3.50
				{ Fixed carbon, - - - 49.00
Volatile matter,	47.50	{		{
				{ Water, - - - 4.50
				{ Gas, - - - 43.00
			100.00	100.00

Coke laminated, vitreous, not swollen.

The cut where this coal shows was partly filled with water, so that a good view could not be had of the seam, to determine its actual thickness. It is a very good block coal.

Analyses of coals from Pike county, collected by Prof. John Collett, and referred to in his report:

THOS. CASE'S COAL L?

On section 19, township 1 north, range 6, near White river, and one mile east of High Bank; color, bright; fracture cubical; contains seams of calcite in the cleavage partings; seam two feet thick.

Specific gravity, 1.280; one cubic foot weighs 80. lbs.

Coke,	-	-	49.50	{
				{ Ash, fawn, - - - 4.00
				{ Fixed Carbon, - - - 45.50
Volatile matter,	50.50	{		{
				{ Water, - - - 3.50
				{ Gas, - - - 47.00

Coke swollen, lustreless, amorphous.

BENNETT'S COAL K.

On section 7, township 1 north, range 7, on Mud creek, near White river, in the northern part of the county; the seam is six feet thick; dull black color; laminated, and breaks into small cubes; it is a caking coal.

Specific gravity, 1.268; one cubic foot weighs 79.25 lbs.

Coke,	-	-	49.00	{
				{ Ash, brown, - - - 3.50
				{ Fixed carbon, - - - 45.50
Volatile matter,	51.00	{		{
				{ Water, - - - 6.00
				{ Gas, - - - 45.00

Coke swollen, laminate and vitreous.

ALEXANDER'S COAL N.

On section 33, township 1 north, range 8, one and a half miles southwest of Petersburg; is a semi-caking coal; the seam is from 3 ft. 6 in. to 6 ft. thick, will average 4 feet.

Specific gravity, 1.284; one cubic foot weighs 80.25 lbs.

Coke,	-	-	52.50	{	Ash, white,	-	-	-	3.00
				{	Fixed carbon,	-	-	-	49.50
Volatile matter,			47.50	{	Water,	-	-	-	6.00
				{	Gas,	-	-	-	41.50
100.00									
				100.00					

DR. POSEY'S COAL K.

Four miles northeast of Petersburg, on sections 12 and 13, township 1 north, range 8; it is ten feet thick and will average about six feet; is a caking coal.

Upper part:

Specific gravity, 1.288; one cubic foot weighs 80.50 lbs.

Coke,	-	-	53.50	{	Ash, lead color,	-	-	-	5.50
				{	Fixed carbon,	-	-	-	48.00
Volatile matter,			46.50	{	Water,	-	-	-	6.50
				{	Gas,	-	-	-	40.00
			<u>100.00</u>						<u>100.00</u>

SHANDY'S COAL K.

Upper part;

On section 13, township 1 north, range 8, near Dr. Posey's; the seam is from 5 to 8 feet thick.

Specific gravity, 1.279; one cubic foot weighs 79.94 lbs.

Coke, - - -	56.50	{	Ash, white, - - -	5.00
		{	Fixed carbon, - - -	51.50
Volatile matter, - - -	43.50	{	Water, - - -	6.50
		{	Gas, - - -	37.00
100.00				100.00

Coke brilliant, lamellar, slightly swollen.

Lower part:

Specific gravity, 1.270; one cubic foot weighs 79.37 lbs.

Coke, - - -	52.50	{	Ash, white, - - -	3.50
		{	Fixed carbon, - - -	49.00
Volatile matter, - - -	47.50	{	Water - - -	6.00
		{	Gas, - - -	41.50
100.00				100.00

Coke lustreless, amorphous, puffed.

This coal is similar in character and quality to Dr. Posey's.

DE BRULER'S COAL K.

On section 8, township 1 north, range 7, two miles north-east of Dr. Posey's, and five miles northeast of Petersburg; this is a caking coal and the seam is from five to seven feet thick.

Top part of the seam:

Specific gravity, 1.294; one cubic foot weighs 80.87 lbs.

Coke, - - -	47.00	{	Ash, blue, - - -	5.00
		{	Fixed carbon, - - -	42.00
Volatile matter, - - -	53.00	{	Water, - - -	8.00
		{	Gas, - - -	45.00
100.00				100.00

Coke very much puffed, lustreless.

Middle part of seam :

Specific gravity, 1.271; one cubic foot weighs 79.43 lbs.

Coke,	-	-	50.00	{	Ash, brown, -	-	-	5.50
				{	Fixed carbon, -	-	-	44.50
Volatile matter,			50.00	{	Water, -	-	-	6.00
				{	Gas, -	-	-	41.00
100.00								
				100.00				

Coke puffed, lustreless.

Lower part of seam :

Specific gravity, 1.268; one cubic foot will weigh 79.25 pounds.

Coke,	-	-	53.50	{	Ash, blue, -	-	-	3.50
				{	Fixed carbon, -	-	-	50.00
Volatile matter,			46.50	{	Water, -	-	-	6.50
				{	Gas, -	-	-	40.00
100.00								
				100.00				

Coke puffed and lustreless.

Good steam and blacksmith's coal.

CROWE'S COAL L.

On section 10, township 1 north, range 7, three miles north of Algiers; color, dull black; seam three and a half to four feet; caking coal with a cubical fracture.

Upper part of seam :

Specific gravity, 1.274; one cubic foot weighs 79.62 lbs.

Coke,	-	-	56.00	{	Ash, fawn, -	-	-	3.50
				{	Fixed carbon, -	-	-	52.50
Volatile matter,			44.00	{	Water, -	-	-	8.50
				{	Gas, -	-	-	35.50
100.00								
				100.00				

Coke puffed, vitreous, amorphous.

Lower part of seam :

Specific gravity, 1.262; one cubic foot weighs 78.87 lbs.

Coke,	-	-	56.40	{	Ash, gray,	-	-	-	8.50
				{	Fixed carbon,	-	-	-	47.90
Volatile matter,			43.60	{	Water,	-	-	-	8.50
				{	Gas,	-	-	-	35.10
100.00									
				100.00					

Coke, - -	59.50	{	Ash, gray, - -	14.00
		{	Fixed carbon, - -	45.50
Volatile matter,	40.50	{	Water, - -	8.50
		{	Gas, - -	32.00
	<u>100.00</u>			<u>100.00</u>

Coke unchanged, dull, laminate.

BARR'S COAL M.

On the bank of the Wabash and Erie Canal, four miles south of Petersburg, on section 15, township 1 south, range 8; is a caking coal and the seam is 2 feet 6 inches thick.

Specific gravity, 1.260; one cubic foot weighs 78.75 lbs.

Coke, - -	60.50	{	Ash, white, - -	3.50
		{	Fixed carbon, - -	57.00
Volatile matter,	39.50	{	Water, - -	7.00
		{	Gas, - -	32.50
	<u>100.00</u>			<u>100.00</u>

Coke puffed, vitreous.

This is a good strong coal for heating purposes.

FALL'S COAL N?

Near Centerville, on section 24, township 1, range 9; the seam is 3 feet 10 inches thick; the upper part, semi-block; while the lower part is a choice caking coal.

Upper part of seam:

Specific gravity, 1.274; one cubic foot weighs 79.62 lbs.

Coke, - -	52.00	{	Ash, fawn, - -	5.00
		{	Fixed carbon, - -	47.00
Volatile matter,	48.00	{	Water, - -	5.50
		{	Gas, - -	42.50
	<u>100.00</u>			<u>100.00</u>

Coke dull, laminate, slightly puffed.

Lower part of seam:

Specific gravity, 1.268; one cubic foot weighs 79.25 lbs.

Coke, - - 55.50	{	Ash, white, - - -	4.00
	{	Fixed carbon, - - -	51.50
Volatile matter, 44.50	{	Water, - - -	7.50
	{	Gas, - - -	37.00
100.00			100.00

Coke vitreous, puffed, amorphous.

DE TAR'S COAL A.

Two miles east of Pikeville, on section 28, township 2 south, range 6; the seam is from 2 to 3 feet thick, the upper part of which is cannel, and the lower part a good article of caking coal.

Upper part of seam:

Specific gravity, 1.444; one cubic foot weighs 90.25 lbs.

Coke, - - 55.50	{	Ash, red, - - -	14.00
	{	Fixed carbon, - - -	41.50
Volatile matter, 44.50	{	Water, - - -	7.50
	{	Gas, - - -	37.00
100.00			100.00

Coke laminate, brilliant, not puffed.

Lower part of seam:

Specific gravity, 1.288; one cubic foot weighs 80.50 lbs.

Coke, - - 54.50	{	Ash, dark red, - - -	5.00
	{	Fixed carbon, - - -	49.50
Volatile matter, 45.50	{	Water, - - -	5.50
	{	Gas, - - -	40.00
100.00			100.00

Coke much puffed, glossy, laminate.

BEE'S COAL K.

Two miles east of the new town of Arthur, on the New Albany and St. Louis Air Line Railway, on section 17, township 2 south, range 7; the seam is eighteen inches thick and is a non-caking coal.

Specific gravity, 1.269; one cubic foot weighs 79.31 lbs.

Coke, - -	58.50	{	Ash, dark brown, -	14.00
		{	Fixed carbon, -	44.50
Volatile matter, 41.50	{	Water, - - -	-	4.50
	{	Gas, - - -	-	37.00
100.00				
				100.00

Coke compact, vitreous, laminate.

MOULTON'S COAL K.

One and a half miles northeast of Winslow, on section 28, township 1 south, range 7; this is a caking coal, and the seam is about 5 feet thick.

The upper part has a laminate structure, is rich in gas, and burns with a large flame.

The middle part is more compact and glossy, and contains some pyrites.

The lower part has a cubical fracture.

Upper part of seam :

Specific gravity, 1.244; one cubic foot weighs 77.80 lbs.

Coke, - -	51.50	{	Ash, lead color, -	3.50
		{	Fixed carbon, -	48.00
Volatile matter, 48.50	{	Water, - - -	-	5.50
	{	Gas, - - -	-	43.00
100.00				
				100.00

Coke much puffed, amorphous, lustreless.

Middle part of seam :

Specific gravity, 1.257; one cubic foot weighs 78.56 lbs.

Coke, - -	59.00	{	Ash, dark red, -	8.50
		{	Fixed carbon, -	50.50
Volatile matter, 41.00	{	Water, - - -	-	4.50
	{	Gas, - - -	-	36.50
100.00				
				100.00

Coke laminate, slightly swollen, lustrous.

Lower part of seam :

Specific gravity, 1.257 ; one cubic foot weighs 78.56 lbs.

Coke, - - - 52.50	{	Ash, white, - - -	3.00
	{	Fixed carbon, - - -	49.50
Volatile matter, 47.50	{	Water, - - - -	6.00
	{	Gas, - - - -	41.50
100.00			100.00

Coke puffed, amorphous, lustreless.

THOMAS' COAL K.

Half a mile north of Winslow, on section 32, township 1 south, range 7 ; the seam is five feet thick, and is a caking coal similar in quality to the above.

Specific gravity, 1.280 ; one cubic foot weighs 80.00 lbs.

Coke, - - - 52.50	{	Ash, white, - - -	4.00
	{	Fixed carbon, - - -	48.50
Volatile matter, 47.50	{	Water, - - - -	7.00
	{	Gas, - - - -	40.50
100.00			100.00

Coke amorphous, puffed and lustreless.

WELLS & WHITMAN'S COAL L.

One and a half miles west of Winslow, on section 36, township 1 south, range 8, and on the south side of Patoka river ; the seam is five feet thick, and is a caking coal.

Upper part of seam :

Specific gravity, 1.294 ; one cubic foot weighs 80.87 lbs.

Coke, - - - 55.00	{	Ash, white, - - -	2.50
	{	Fixed carbon, - - -	52.50
Volatile matter, 45.00	{	Water, - - - -	8.00
	{	Gas, - - - -	37.00
100.00			100.00

Coke slightly puffed, laminate, vitreous.

Middle part of seam :

Specific gravity, 1.278 ; one cubic foot weighs 79.87 lbs.

Coke, - -	52.50	{	Ash, white, - -	2.00
		{	Fixed carbon, - -	50.50
Volatile matter, 47.50		{	Water, - - -	6.00
		{	Gas, - - -	41.50
100.00				100.00

Coke puffed, vitreous, laminate.

Lower part of seam :

Specific gravity, 1.275 ; one cubic foot weighs 79.68 lbs.

Coke, - -	53.00	{	Ash, white, - -	2.50
		{	Fixed carbon, - -	50.50
Volatile matter, 47.00		{	Water, - - -	5.00
		{	Gas, - - -	42.00
100.00				100.00

Coke puffed, vitreous, laminate.

This is altogether a most excellent coal and well adapted for steam, manufacturing and household uses.

G. W. MASSEY'S COAL L.

On the south bank of Patoka river, two miles north of the New Albany and St. Louis Air Line Railway, on section 4, township 2 south, range 8 ; this is a caking coal and the seam ranges from 6 to 10 feet in thickness.

Upper part of seam :

Specific gravity, 1.268 ; one cubic foot weighs 79.25 lbs.

Coke, - -	57.00	{	Ash, light gray, - -	3.50
		{	Fixed carbon, - -	53.50
Volatile matter, 43.00		{	Water, - - -	8.50
		{	Gas, - - -	34.50
100.00				100.00

Coke brilliant, compact, laminate.

Lower part of seam :

Specific gravity, 1.279 ; one cubic foot weighs 79.93 lbs.

Coke, - -	56.50	{	Ash, white, - - -	1.50
		{	Fixed carbon, - - -	55.00
Volatile matter, 43.50		{	Water, - - -	7.00
		{	Gas, - - -	36.50
	100.00			100.00

Coke brilliant, slightly puffed, laminate.

This is a good coal for general fuel and steam purposes.

THOMAS MARTIN'S COAL L.

One and a half miles north of the N. A. & St. L. A. L. Ry., on section 9, township 2 south, range 8; the seam is from 7 to 9 feet 6 inches thick, and is a caking coal.

Upper part of seam :

Specific gravity, 1.258 ; one cubic foot weighs 78.62 lbs.

Coke, - -	55.50	{	Ash, gray, - - -	3.50
		{	Fixed carbon, - - -	52.00
Volatile matter, 44.50		{	Water, - - -	7.50
		{	Gas, - - -	37.00
	100.00			100.00

Coke, much puffed, vitreous, amorphous.

Middle part of seam :

Specific gravity, 1.269 ; one cubic foot weighs 79.31 lbs.

Coke, - -	60.00	{	Ash, light gray, - - -	3.00
		{	Fixed carbon, - - -	57.00
Volatile matter, 40.00		{	Water, - - -	6.50
		{	Gas, - - -	33.50
	100.00			100.00

Coke puffed, vitreous, amorphous.

Lower part of seam :

Specific gravity, 1.275 ; one cubic foot weighs 79.68 lbs.

Coke, - -	57.50	{	Ash, white, - - -	2.50
		{	Fixed carbon, - - -	55.00
Volatile matter, 42.50		{	Water, - - -	7.50
		{	Gas, - - -	35.00
	100.00			100.00

Coke puffed, vitreous, slightly laminate.

This is a splendid, mammoth seam of coal, well adapted for steam and household uses.

P. S. TEVAULT'S COAL K.

Three miles east of Pleasantville, on section 16, township 3 south, range 7; the seam is about 5 feet thick caking coal and a very good fuel.

Specific gravity, 1.245; one cubic foot weighs 77.81 lbs.

Coke, - - -	52.50	{	Ash, white, - - -	3.00
		{	Fixed carbon, - - -	49.50
Volatile matter, - - -	47.50	{	Water, - - -	7.00
		{	Gas, - - -	40.50
100.00				100.00

Coke much puffed, amorphous, lustreless.

The analyses of the following coals from Warrick county will serve to show their relation to the coals of Dubois and Pike counties.

WOOD'S COAL K.

Two miles southeast of Holland, on section 19, township 4 south, range 5; this is a caking coal, and the seam is three feet thick. It is a good coal, contains a large percentage of gas, burns with a large flame, and is considered excellent for blacksmithing.

Specific gravity, 1.272; one cubic foot weighs 79.50 lbs.

Coke, - - -	48.00	{	Ash, white; - - -	3.00
		{	Fixed carbon, - - -	45.00
Volatile matter, - - -	52.00	{	Water, - - -	4.50
		{	Gas, - - -	47.50
100.00				100.00

Coke much puffed, lustreless, amorphous.

INGHAM'S COAL K?

Two miles north of Taylorsville, on section 5, township

3 south, range 6 ; this is a block coal, and the seam is two feet six inches thick.

Upper part of seam :

Specific gravity, 1.280 ; one cubic foot weighs 80. lbs.

Coke, - -	51.00	{	Ash, white, - -	2.00
		{	Fixed carbon, - -	49.00
Volatile matter, 49.00		{	Water, - - -	7.50
		{	Gas, - - -	41.50
	<u>100.00</u>			<u>100.00</u>

Coke slightly puffed, laminate, vitreous.

Lower part of seam :

Specific gravity, 1.311 ; one cubic foot weighs 81.93 lbs.

Coke, - -	52.50	{	Ash, white, - -	2.00
		{	Fixed carbon, - -	50.50
Volatile matter, 47.50		{	Water, - - -	6.50
		{	Gas, - - -	41.00
	<u>100.00</u>			<u>100.00</u>

Coke laminate, vitreous, not puffed.

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PERRY COUNTY.

This county was organized in 1814, and named in honor of the gallant Commodore Oliver Hazard Perry.*

It is bounded on the north by Dubois and Crawford counties, on the east by Crawford county and the Ohio river, on the south by the Ohio river, and on the west by Spencer and Dubois counties.

It is divided into seven civil townships—Troy, Tobin, Union, Leopold, Oil, Clark and Anderson.

The tortuous course of the Ohio river gives to this county a river front of about fifty miles, and its interior is also well supplied with water by the numerous rivulets which find their way to that stream and to Anderson creek; a large tributary which flows along the western border of the county in a southerly direction to its confluence with the Ohio.

The direction taken by the main water courses in this county is, in a great measure, due to the character of the rocky strata which gives prominence to its geology.

The hydrographic basin through which the Ohio river winds its way to the great Mississippi river, crosses the outcrop edges of the geological strata at nearly right angles to their line of strike. Whenever, therefore, the stream encountered a stratum that offered more than ordinary resistance to abrasion, the course of the river is turned from its main direction and compelled to take a northerly or southerly one, following very nearly, if not quite, along the line of strike

*Indiana Gazetteer.

until it reached a part which offered less resistance, or when accumulating, it acquired sufficient force, broke through the rocky barrier. The Wabash river, and White river with its two principal branches—the East and West Forks—flow across the State of Indiana from east to west, with northerly and southerly bearings that conform very closely to those taken by the Ohio. This indicates that they cross the same strata, and have the same geological difficulties to contend with. The Wabash river, when it reached the heavy bedded sandstone of the millstone grit series, on the western border of the State, near Williamsport, in Warren county, turned its course, and flowing in a southerly direction, along the general outcrop lines of the carboniferous strata, cut its way to its confluence with the Ohio, between bluffs of sandstone which here and there present bold escarpments.

The directions taken by the Ohio river to overcome the geological difficulties in its way may be compared to the course taken by a ship when tacking to make way against a head wind.

This generalization regarding the influence of the geological strata in directing the course of rivers is, at this time, very crudely presented, but with the progress of the survey I hope to bring forward an array of facts obtained by detailed observations that will serve to more fully illustrate this subject.

If we look at the map, it will be seen that the Ohio river, on reaching Perry county, turns in a southerly direction and flows along the outcropping edges of the lower carboniferous limestones with but little if any change in geological levels, until a point is reached near Cloverport, where it crosses the obscurely basetting edges of the strata and cuts its way in a northerly direction across the millstone grit, which it first meets in great force near the mouth of Deer creek, and that it is only when it reaches Troy that it has found a geological level about 100 feet above the millstone grit. From Troy, the course is southerly and again approaches the outcropping line of the rocks and crosses

the last barrier of millstone grit in Indiana at Rockport, where it is represented by the "Martha Washington Rock."

The head waters of Anderson creek cross the strata from east to west in a corresponding manner, and the main body of the stream keeps along the strike line of the strata to its mouth, and the Cannelton seam of coal may be found by outcrops or shallow shafts from St. Meinrad's, in the edge of Spencer county, to Troy. Deer creek follows the same law, but its bed occupies a little lower geological level, and the lower carboniferous limestone is seen along the main stream and its eastern branches.

By far the greater portion of this county is broken, and the hills, which are from two to four hundred feet in height, are often capped with massive sandstone, which gives rise to picturesque and rugged scenery, but affords no great attraction for the agriculturist. In the valleys, however, there are small streams with narrow fertile borders and the extensive bottoms along the Ohio river are unsurpassed in fertility.

The location of the seat of justice has been changed twice since the organization of this county. It was first located at Troy, on the Ohio river near the mouth of Anderson creek. From Troy it was removed to Rome, on the Ohio river in Tobin township, and finally found a resting place at Cannelton, where, in all probability, it will remain.

Cannelton is a flourishing town and has long been noted for its mining and manufacturing enterprises. It was first laid out in 1835, and very soon afterward was purchased by the American Cannel Coal Company. This organization with a capital of \$500,000, purchased 7,000 acres of land adjoining the town, most of which was underlaid with coal. The object of this company was to avail themselves of the advantages which this location offered for procuring cheap fuel at the lowest possible rates, and to build up manufactures on a large scale. To carry out these views and to promote the growth of the town, large lots were laid out for cotton and other mills; coal mines were opened and railroads laid from thence to the river; and coal was furn-

ished at a rental of one cent per bushel to manufacturers. Charters were obtained for the erection of two cotton mills, but only one, the Cannelton Cotton Mill which is now in successful operation, was built. As a reflex of the views held by the American Cannel Coal Company I quote a paragraph from the Indiana Gazetteer published in 1849, page 353.

"This enterprise is intended to be but the beginning of a movement which may result in giving the control of the price of cotton to the country where it is produced. It may, too, operate as a check to over production by giving cotton planters other means of investment besides lands and slaves, and it may result in changing the character of the present cotton manufacturing districts of the world, for the coal districts in the vicinity and the fertile and healthy regions around present opportunities for the increase of manufactures to unlimited extent. The wealth of Indiana may eventually be concentrated in this part of the State which was so long overlooked by immigrants. The present improvements at Cannelton owe their origin to General Seth Hunt, of New Hampshire, a man of singular intelligence and energy, who, in connection with Messrs Hobart, Williams and Russell, then wealthy capitalists of Boston, formed the American Cannel Coal Company, purchased the lands and made several entries to the coal strata." * * *

The Cannelton Cotton Mill is built of grayish brown sandstone, procured from the hills just back of the mills, and is 272 feet long, 65 feet wide and four stories high. In elegance of design and general appearance these mills are unsurpassed, if equaled by any in the country. I was shown through the building by Mr. James Lee, the intelligent and courteous gentleman in charge of the engine, which is placed in a room as neat as a parlor and kept scrupulously clean. The mill contains 10,800 spindles, 372 looms, employs 375 hands, uses 13 bales of cotton and turns out 15,000 yards of standard brown sheeting per day. The mill has recently been repaired and fitted up with the most approved new machinery, purchased in England, at a cost of about \$100,000.

The Hon. Hamilton Smith is at present, and has been for many years, President and chief manager of the American Cannel Coal Company's business, and it is to this distinguished gentleman, more than to any other, that Cannelton owes its mining and manufacturing prosperity. He is a man of high intellectual culture; the walls of his dwelling are adorned with rare paintings, some of which are by the "old masters" and of great value, and his library is probably the largest and most valuable in the State. He has made Cannelton his home since its purchase, which through him was accomplished for the Company, and with his family and books for companions, he has given his time to the study of the great work before him; and as the result of his far-seeing policy, probably nowhere in the country is coal mining managed so completely to the satisfaction of the miner and owner. The secret of the success which attends President Smith's management of these mines may be traced to the fact that most of the employes have been induced to become property owners. I was informed that he had himself made over four hundred and fifty-two free holders. Being owners of homesteads they have a common interest in the general prosperity of the country and the success of the mining enterprises upon which they are dependent for the means of supporting their families. For this reason, also, they are generally sober, industrious men, who send their children to school and accumulate wealth.

Belonging to the Cotton Mill Company there is a mill for making cotton batting. Three bales of cotton are worked daily into batting, and the engine does the double duty of pumping water from the Ohio river to supply the cotton mill.

The other important manufactures of Cannelton are Clark Brothers' extensive stoneware sewer pipe manufactory. These pipes are from three to twenty-two inches in diameter. The clay used in their manufacture is the bottom or fire-clay immediately under the "top coal." The seam is three to six feet thick and the clay is well adapted for the purpose. The pipes are hard, close-grained, very strong, perfect in

shape and free from cracks and flaws. Their kiln is one of the largest in the country and they turn out about fifty thousand dollars' worth of pipes per year. About three hundred and fifty bushels of coal are required to burn a kiln. They employ about twenty hands. Close by this sewer pipe manufactory is William Clark's stoneware, fruit-jar and milk-pan pottery. This ware is made of clay from the same seam worked by Clark Brothers, and by the aid of an ingenious machine which Mr. Clark has invented for washing the clay, he is enabled to make a superior article of milk-pans. He burns about eighteen thousand crocks a month, and the ware sells readily for eight and a half cents per gallon at the works.

A chair factory owned by Bunts & Smith, and a paper mill owned by the Paper Mill Company, F. Sulzer, President, and Roan Clark Secretary, were built this year, and were about ready to commence operations in November.

Besides the above named factories there are a number of lesser establishments which also serve to point to the general prosperity of the place. Of these I can not pass unnoticed a small mill for crushing and pulverizing bones for fertilizing purposes. It is owned by Mr. Henry Hicks, and though simple in its construction answers the purpose well for which it was designed. It has three cast iron stamps, each weighing about 350 pounds, that are raised and dropped alternately upon the bones which are placed on an iron slab forming the bottom of a box under the stamps. The bones are by this means pulverized into a fine powder, and the daily product of the mill is 500 pounds. Mr. Hicks pays half a cent per pound for bones and sells the prepared dust at two and a half cents. Forty pounds scattered over an acre of ground, or a tablespoonfull to a hill of corn is the usual quantity used for fertilization. The yield of all kinds of grains, grasses and root crops is materially increased by the use of bone dust, and there is ready sale for all that the mill can make.

TELL CITY.

This flourishing young city, growing upon our southern border with a rapidity that is truly remarkable, is situated on the Ohio river, three miles below Cannelton, one hundred and twenty-five miles below Louisville and seventy-five miles above Evansville. The site was purchased in 1858 by the Swiss Colonization Society, a colony of generous men who were attracted to the locality on account of the coal which gave a surety of cheap fuel, and the fine oak, poplar, walnut, hickory and other trees which would supply timber for manufacturing purposes. They at once commenced to lay out the town and build houses where they could enjoy freedom and reap the full benefit of their labor. The principal streets are graded and Macadamized with gravel and ferruginous clay, obtained from the hills near by. This material cements and makes a hard, durable road. There are no drones in the town which is now said to contain a population of about three thousand. And by persevering industry, and encouraging and extending aid to mechanics who settle among them, manufactures have been built up which are now turning out many thousands of dollars worth of goods that find a ready market in the towns to the south and west.

The following are the most important manufactures: Tell City Furniture Company, organized in 1859 on a capital of ten thousand dollars, now represents a capital of two hundred thousand dollars; employs one hundred hands and turns out a hundred thousand dollars worth of goods annually.

The Cabinet Makers' Union was organized in 1868. They employ eighty-five men, and turn out seventy-five thousand dollars worth of furniture annually.

Coombs, Hartman & Company's Chair Factory employs sixty-five men, and makes annually seventy thousand dollars worth of chairs.

Chair Makers' Union. This company employs twenty-

five men, and makes thirty thousand dollars worth of chairs annually.

Herman & Brothers. This firm commenced manufacturing their patent axle-wagons in 1866 on a very limited capital, which by industry and the superiority of their work, was very rapidly increased, so that now they are employing thirty men and sell annually forty thousand dollars worth of wagons. These wagons are held in high esteem and meet with a ready sale in the Southern and Western States.

Lyon & Sedletsy, is a firm recently organized for the purpose of erecting a furniture factory. The building and machinery are nearly ready for operation, and they will employ about seventy-five men.

Sylvester Raney, an enterprising young man, is erecting a barrel and stave factory, which will be in operation by the close of the year.

The Tell City Planing Mill Company have a large establishment and are doing a fine business.

Wildman & Obousier have a foundry and machine shop, and also build engines. Their business is lucrative and growing.

Tell City Woollen Mills, owned by Michael Bettinger, is manufacturing Bettinger's "Gold Medal" Yarns. His business averages about twenty-five thousand dollars a year.

Charles Steinauer & Co. have a merchant mill which is turning out a large quantity of flour and mill feed.

Zines & Kappler's foundry for stoves and all kinds of castings is also doing a large amount of work.

F. Voelke has a large brewery and is shipping beer and ale to all the towns on the river to the south.

Charles Becker has a brewery and is also making considerable beer.

John Olrecht has an establishment for manufacturing brush-blocks and brushes; his blocks are shipped to all parts of the United States.

The Excelsior Saw Mill is owned by John Menninger, and cuts a large quantity of plank.

The shingle factory of Jacob Ruff is producing about twelve thousand shingles.

There is, also, here a distillery for making apple and peach brandy.

Besides the above there are a number of manufactories of less importance, but enough have been enumerated to show the prosperous condition of the city, and illustrate its rapid growth.

The city is also well supplied with merchants, who deal in all the commodities required by the country, and to facilitate trade Messrs. Whitton & Steiner have established a banking house which is doing a fine business.

Facilities for education have not been neglected by these busy people, for they have two large brick school houses where the children receive instruction in both the German and English languages.

The extent and marvelous growth of manufactures at this point furnishes a striking example of what a frugal and industrious people may accomplish by aiding and encouraging one another. All the manufacturing companies commenced with small means but they have managed to increase their business and accumulate fortunes.

The Swiss Colonization Society still offer to give town lots and otherwise assist all worthy mechanics who desire to start any branch of manufacturing business in their city.

Four miles below Tell City is the town of Troy, somewhat noted for its manufacture of Yellow or Troy ware. Some years ago a large company, consisting mostly of English capitalists, was organized to build extensive potteries at Troy, under the impression that the clay under the so-called "top seam" of coal would answer to make the ordinary white queensware; but after erecting the necessary buildings and large kilns they found that this clay was only suited for making yellow ware, and the pottery was finally abandoned and let go to ruin.

Two potteries have subsequently been started here and are doing a very fair business by making the Yellow or Troy ware. One of these potteries is owned by Samuel Wilson,

and the other by B. Hinch. The former makes annually about five thousand dollars worth of this ware and the latter not quite so much.

On Anderson creek, near Troy, there is a large establishment for making sash, doors and blinds.

Leopold, Rono, Derby and Rome are small towns; the former is in the interior of the county and settled principally by French. The Catholic Church at this place is an imposing structure, built of gray sandstone quarried in the neighborhood. Rono and Derby are thriving towns situated on the Ohio river. Rome, also on the river, is seven miles below Derby and has a fine location on the rich alluvial "bottom," but has decreased in population since the removal of the county seat to Cannelton. There are no other towns of any note in the county.

Between Cannelton and Tell City is a place called Fulton; there are no houses here, and the name is applied to an abandoned coal mine, which is on a tract of land that was given by the United States Government to Robert Fulton, the inventor of the steamboat who, in company with Mr. Livingston built, at Pittsburg, Pennsylvania, in 1812, the first steamboat that ever floated on the Western rivers; it was called the "Orleans" and made her first trip from Pittsburg to New Orleans in fourteen days.

It is said that this boat, on her first trip down the Ohio river, stopped at Fulton, and some coal from the mine was taken on board, whether for fuel or as a matter of curiosity, is not known.

It is proposed to erect at this place a monument in honor of Fulton; and it is to be hoped the project will be carried out. The location is a proper one, for no where has the invention of Fulton been more productive of beneficial results, or is more fully appreciated than on the beautiful Ohio. And a monument here would not only serve to remind the navigator of his obligations to genius, but will also serve to illustrate the ingratitude of a Republic, which, in possession of an almost boundless domain, could spare only a few acres, where it was of little value, to reward one

of its greatest benefactors. For who can estimate the value of Fulton's invention to a country so bountifully supplied with large rivers, and where its application has been productive of such marvelous results in developing its resources.

GEOLOGY.

The geological formations of this county embrace a portion of the lower carboniferous rocks, the greater part of the coal measures; a ferruginous gravel and sand which has by some been thought to belong to the tertiary; glacial drift, and a few patches of quaternary on the highest points along the Ohio river.

The following section will exhibit the sequence of the strata, leaving out the ferruginous gravel as its relative position with the drift has not been ascertained:

GENERAL SECTION IN PERRY COUNTY.

SPACB.		Fr.	In.	
58.0		5.		Soll and clay.
		10?		Loess (local).
		15.		Drift (local).
		23		Sandstone and Shistose Sandstone.
2.6		2	6	COAL L.
50.0		?		Fire clay.
		35		Sandstone.
		15		Limestone.
2.6		2	6	COAL K.
50.0		?		Fire clay.
		50		Sandy shale.
.6			6	COAL I.

GENERAL SECTION—Continued.

SPAC.		Fr.	In.	
30.0		30		Sandstone.
1.0		1		COAL H.
		1		Fire clay.
91.0		90		Heavy bedded gray sandstone.
				Cannelton building stone.
1.6		1	6	COAL G. "Top Coal."
		4		Fire clay. Potters' clay.
44.0		40		Gray shale with ironstone.

GENERAL SECTION—Continued.

SPACE.		FT.	IN.	
4.0		4		COAL F. Main "Cannelton seam."
		5		Fire clay.
60.0		4		{ Thin bedded sandstone and Schis- tose sandstone.
		15		Sandy shale.
1.0		1		COAL D ?
		4		Fire clay.
		5		Shaly sandstone.
84.0		45		Thick bedded sandstone. Lower building stone.
		30		Sandy shale.
.6		6		COAL B.
		1		Fire clay.

GENERAL SECTION—Continued.

SPACE.		FT.	IN.	
50.0		50 to 70		{ Conglomerate massive sandstone with pebbles.
2.6		2	6	COAL A.
		2		Fire clay.
		50 to 90		Sandy shale and massive sandstone.
		80		{ Greenish marly shales alternating with pentramital and Archime- des limestone.
205.3				

GENERAL SECTION—Continued.

SPACE.		Fr.	In.	
		70		Gray Archimedes limestone.
		5	2	Bituminous shale.
.3			2	Coal.
		20		Sandstone.
100.0		80		Gray limestone.
				Ohio river at Rome.
833.3	Total.			

St. Louis Limestone. The gray limestone at the base of the above column is the equivalent of the sub-carboniferous member designated in the Missouri and Illinois Geological Reports, as the St. Louis limestone. At St. Louis it contains a number of beautiful and interesting fossils, among which are *Palæchinus multipora*.

This limestone may be seen along the banks of the Ohio river and in the valley over a greater part of the county east of Deer creek. The prevailing color is light gray with occasional layers of fine grained lithographic stone; but the latter generally contains too many crystals of calcite to be made available for lithographic purposes. So far as my examination went, this member contains but few fossils.

There are various reports of lead being found in this limestone on Poison creek and it is possible that it may contain isolated small pieces of galena; but no true veins of galena are likely to be found in this county.

Every county, where hills and rocks prevail, has its Indian tradition relating to the existence of rich mines of lead and precious metals. When engaged on the survey in Kentucky, I remember hearing the story of "Swift's Silver Mine" and its location from what was considered indisputable evidence in every county in the State from the Ohio river on the west, to the Big Sandy river on the east, and it is possible that I might have followed the tradition into Virginia. Thus the poor lazy Indians who never worked mines or engaged in the smelting of ores in all their lives, are the will-o'-the-wisps which credulity have conjured up to lead even some of the best informed citizens to search after imaginary mines where enough silver may be had to shoe all the horses in the country, or where lead ore exists without limit. Indeed, it would be difficult to estimate the amount of money and valuable time spent in these fruitless searches. It becomes, therefore, one of the important duties of the geologist to disabuse the public mind regarding the faith to be placed in these traditional mines, as the knowledge of what minerals are not to be found, puts a stop to misdirected capital and enterprise. It is well to bear in

mind that it is hazardous enough to work mines when a portion of the mineral is all the time in view.

The lower carboniferous rocks are metaliferous in many parts of the world, but most generally in localities where metamorphism has played a prominent part and crystalline rocks prevail. The gold bearing quartz veins of the Placer mountain in New Mexico, traverse rocks of this age and pass upward into quartzite sandstone which is referable, in my opinion to the carboniferous. So, at the Organ mountains in the southern part of the territory near Las Cruces, the silver ore is found in veins cutting through the sub-carboniferous limestone which is here crystalline and capped with porphyry. The latter rises up in great columns resembling organ pipes, and hence the name of the mountain.

In Crittenden and Livingston counties, Kentucky, and in Hardin county, Illinois, there are in the St. Louis limestone broad veins of fluor spar, containing more or less lead. These veins are very promising and a great deal of money has been spent in their development, but, so far as I can learn, without a compensating return. It is true, that furnaces have been built and considerable lead ore mined and smelted into pigs in Illinois, but this fact does not settle the question of profit. This member is also the repository in Kentucky and in Hardin county, Illinois, of hydrated oxide of iron, in large beds or pockets.

Above the St. Louis limestone is an intercalated sandstone, on which rests the Archimedes limestone of the Illinois Reports, alternating with greenish marly shales. In places the limestone is quite rich in characteristic fossils, *Archimedes*, *Pentramites*, etc.

In the associated shales are occasional thin bands of clay ironstone. A seam of coal from one to six inches thick, is also found in this member in connection with a seam of bituminous shale; it is not continuous, but may be seen locally, from Leavenworth, in Crawford county, to Deer creek. Near Rome and at other points, much time has been lost and money spent in digging into this black shale with

the hope that the coal would prove to be thick enough to mine when followed a considerable distance into the hill. I have never found or heard of a seam of coal, below seam A of the above column, that was over six to eight inches thick, and as a rule, when a seam has acquired a roof of solid slate or other rock, the thickness is just as likely to diminish as increase by pursuing it to a greater distance from the outcrop.

Above the Archimedes limestone is a massive sandstone attaining in some places, including the sandy shales and flags, a total thickness of one hundred feet or more. A portion of this sandstone member, is in a solid bed forty to sixty feet thick without seams; but occasionally you find the exposed face roughened by lines of false bedding and irregular markings of oxide of iron which stand out in bold relief from the weathered surface. "The Hon. James Hardin, whose hospitality I enjoyed while in this portion of the county, very kindly drove me in his buggy to a locality near Rome where this sandstone is seen in great force, and I obtained there the following section, the measurements of which were taken with the aneroid barometer.

Section of the rocks at Cedar Lick Hollow, one and a half miles northwest of the residence of Hon. James Hardin, on section 6, township 7 south, range 1 west:

CEDAR LICK HOLLOW.

SPACE.		Fr.	In.		
		4.		Sell and covered.	
94.		60.		Brown colored massive sandstone.	Chester sandstone.
		20		Shaly sandstone.	
170.		80		Greenish marly shale and Pentramital limestone.	Upper Archimedes limestone.
		70.		Gray Archimedes limestone.	

CEDAR LICK HOLLOW.—Continued.

SPACE.		Ft.	In.	
		20.		Buff sandstone. { Upper Archimedes limestone.
80		40.		Gray limestone. {
				St. Louis limestone.
	.	40.		Covered to high water of Ohio river. }
344	Total.			

This section extends from the high water mark of the Ohio river to the top of the ridge, and represents 340 feet of lower carboniferous strata, and, including a portion of the St. Louis limestone group, all of the upper Archimedes limestone and the greater part of what is called in the Illinois Reports, the Chester sandstone group.

The topography of the country where this succession of strata prevails, is characterized by rugged hills and long narrow ridges that are lined on one or both sides, near the top, with cliffs of massive sandstone; and scattered over the precipitous escarpments to the valley below, are immense quadrangular blocks of sandstone that have broken loose and fallen from the parent bed above. One of these blocks measures 120 by 80 feet and is estimated to be 50 feet high. Several large cedar trees are growing on the top of it. The washing away of the shales and the destruction of the lower part of the sandstone cliff by weathering has produced large

cavities; the so-called "Rock Houses." In one of these "rock houses" I saw several Indian graves that were walled with stone. They are about four feet long and two feet wide. From time to time they have been dug into, and it is said that a few arrow heads and stone axes have been taken out. A quantity of flint flakes and a few fragments of human bones were seen in the dirt. I believe that a careful search in the bottom of this cave will bring to light, not only relics and human bones, but also the bones of quadrupeds and other animals, some of which may prove to be new to science. In a large sandstone rock which had fallen from above and which lies near the mouth of the cave but entirely beyond the roof, there are two ovoid holes about two feet apart. Their largest diameter at the mouth is eight inches, shortest diameter six and a half inches, depth twenty-two inches, width at bottom about three inches. The top of the rock, on the upper side, is about two and a half feet above the ground. The direction of these holes is vertical, but, from the position of the rock, they run diagonally across the lines of bedding. At a rock house in the conglomerate sandstone, in another part of the county, I saw similar holes but paid little attention to them, supposing them to be "pot holes," that is holes formed by the abrading action of pebbles kept in motion by the action of running water. But here the position of the rock and all the surroundings precluded the possibility of their having been produced by such agencies, and these holes must be looked upon as the work of Indians; most likely of the "Mound Builders." To what uses they were put is a matter of conjecture, but it is most probable that they served as mortars in which to crush acorns and roots for food. The long pestle-shaped stones, which are not uncommon relics of the Mound Builders, would find in these holes a mortar suited to their length. Their great depth may result, in part at least, from the gradual wearing away of the sandstone by the act of pounding with a pestle made of much harder stone.*

*The long cylindrical stones called pestles or hammer stones are usually of trap or greenstone and are very hard.

This sandstone is also seen at the base of the hills and exposed in the bank of the Ohio river, just above Rock Island. In places it is suitable for building stone and may be quarried in blocks of any required size.

Millstone Grit or Conglomerate.—These terms are applied indiscriminately to a massive sandstone that is often charged with quartz pebbles, and lies at the base of the coal measures. The millstone grit is seen over the greater part of Perry county and is here represented by sandy shales, flags, and a massive sandstone containing quartz pebbles.

In many parts of the county, coal seam A, which underlies this conglomerate sandstone, is from two to two and a half feet thick and the quality is good. At Rock Island, just above Cannelton, it is entirely absent or is only represented by a few inches of coal as may be seen by the following section, given by Joseph Lesley, Jr., in the report made by the former State Geologist, Professor Richard Owen, (1859. pp. 343, 344):

SECTION OF THE ROCKS NEAR THE MOUTH OF
DEAR CREEK.

SPACE.		Fr.	In.	
		77		Thin bedded sandstone.
151.		4		Ferruginous sandstone.
		70		Thick bedded sandstone. Building stone.
1.6		1	6	Top coal vein.
48.		48		{ Gray shales with thin bands of nodular iron ore.
4.		4		Main Cannelton coal.
		5		Fire clay.
53.		53		{ Shales and Schistose sandstone with heavy band of kidney iron ore.
1.1		1	1	Lower coal vein.
		4		Fire clay.
		10		Shales.

SECTION OF THE ROCKS—Continued.

SPACE.		Ft.	In.	
20		40		Thick bedded sandstone.
		55		Thin bedded sandstone.
125				Coal streak.
		70		Massive sandstone & conglomerate.
		55		Probably sandstone.
				{ Top of Subcarboniferous Limestone at mouth of Deer creek.
477.7	Total.			

Mr. Lesley made a topographical map of the country around Cannelton which was not published, and I presume it is lost, as I have not been able to find or learn anything of it. This is to be regretted, as the work of so able a topographer could not fail to be of practical as well as of scientific value.

The section given above shows at least 422 feet of coal measures and millstone grit, and in this depth we have represented by massive sandstones nearly the entire coal measures of the State, with only one workable seam of coal; the main Cannelton coal, which is referable to F of my classification. The sub-conglomerate coal A, is also wanting in this section, but shows in the cliff a short distance to the west, where it is only a few inches thick.

At Godfried Everard's on sections 10 and 11, township 5 south, range 2, one and a quarter miles southwest of Leopold, coal A is thirty inches thick and of very good quality. It has been mined on a small scale for smithing, and I was told that it answered the purpose very well. It has a glossy black color, but contains some seams of pyrites. The bituminous brown shales over the coal contain a variety of fossil plants, but in such a bad state of preservation that they would not bear handling. The principal kinds noticed are: *Lepidodendron* sp.?, *Neuropteris Loschii*, *N. hirsuta*, *Sigillaria* sp.?, and some stems of plants.

The section from the top of the hill to the coal is :

SPACE.		Fr.	In.	
101.0		30		Covered.
		70		Flags and massive conglomerate sandstone with pebbles.
		1		Bituminous brown shales.
2.6		2	6	COAL A.
		1		Fire clay.
317.0		30?		Covered space to the foot of ravine.
		?		Sub-carboniferous limestone.
134.6	Total.			

A weathered specimen of coal obtained from the mouth of the mine gave, on analysis :

EVERARD'S COAL A.

Coke, - -	55.50	{	Ash, red, - - -	1.50
			Fixed carbon, - - -	54.00
Volatile matter, 44.50		{	Water, - - -	7.50
			Gas, - - -	37.00
	100.00			100.00

Coke puffed, amorphous with metallic lustre.

At Mrs. Foster's on section 11, same town and range as above, we have the same succession of strata, and coal A outcrops under a heavy cliff of conglomerate sandstone which appears on all sides of a deep ravine. This cliff contains a number of caves, "rock houses," which are similar in appearance to those seen near Rome. At the mouth, they are from three to ten feet high and the roof slopes back until it reaches the floor. The depth seldom reaches twenty feet. Here one is called the Saltpeter cave, and it is said that nitre has been extracted from the dirt which exists in limited quantity on the bottom; another is called the Indian Mortar cave. Within the mouth of this cave is a large stone that has fallen from the roof in which there is a number of round holes about six inches in diameter, one to two feet deep and tapering down to their bottom. At that time I could not conceive of any use to which such narrow deep holes could be put, and notwithstanding the careful memorandum then made that the rock containing them was situated too far within the rock house for dropping water to reach it, and that there was no evidence showing that any body of water had ever issued from the cave, still I was loth to believe them artificial and left the spot fully persuaded that they were produced in some unaccountable way by the action of water. But I have now not the slightest doubt that they are the work of the Aborigines. I picked up a flint arrow-head at the mouth of this rock house, and it is possible that many interesting relics and bones of animals could be found by digging up the bottom. In a field belonging to Mr. Peter Fealy, which is on the ridge near by, flint flakes are to be seen in great abundance, and Mr. Fealy says he finds numbers of flint spear heads, arrow heads and stone axes every spring when he plows the field. Indeed there is no want of evidence to show that the rock houses formed the abode of Indians, but whether Mound Builders or more recent races, or both, is a question which can only be satisfactorily answered by more extended researches.

The massive conglomerate sandstone in which the rock houses occur, contains a few pebbles, and the exposed face is

in many places at least forty feet thick and without a seam. The coal which lies below it, though too thin to be of commercial value, is found in most of the hills bordering on Deer creek and Little Deer creek, and on the headwaters of Anderson, and the Middle and Sulphur Forks of Anderson creek. The sub-carboniferous limestone is exposed in many of the ravines below it.

At Mr. Abraham Lusher's, on section 7, town 4, range 2, the sub-carboniferous limestone outcrops at the base of the hill, and coal A is about thirty feet above it. It has been dug into by Mr. Lusher, and it is said to be two feet thick. The opening which had been made was filled up with washings from above, and I was unable to find any good specimens for analysis in the debris.

In the shales under the coal seam there are bands of good ironstone, but the extent of this ore could not be ascertained. The pieces picked up were three to four inches thick.

The following is a section of the rocks taken from the creek at Mr. Lusher's house to the top of the ridge:

SPACE.		FT.	IN.	
200.		200		{ Covered space, mostly sandstone and shales.
?		?		COAL B. Thin.
40		40		Massive sandstone.
2		2?		COAL A.
		1		Fire clay.
		30		Gray shales.
71		40		Archimedes limestone. Sulphur Fork.
213.	Total.			

This coal has also been dug into at the following places:

Cutter tract, section 20, township 4, range 2.

Wm. Lanman's, section 31, township 4, range 2.

Holman, section 33, township 4, range 2.

A. Lusher's, section 27, township 4, range 2.

Flamin's, section 20, township 3, range 2.

Sproule & Bugger's, section 21, township 3, range 2.

Unknown, section 2, township 4, range 2.

Platts', section 24, township 3, range 3.

Mrs. Baird's, section 12, township 4, range 3.

J. Lazenby, section 29, township 5, range 2.

F. Mack, section 26, township 5, range 2.

J. Pollock, section 26, township 6, range 2.

J. C. Shoemaker, section 22, township 4, range 2.

At Leopold, near the base of the conglomerate, on land belonging to Henry Deville, sections 1 and 2, township 5, range 2, and on John Morgan's land, section 12, township 5, range 2, there are deposits of hydrated oxide of iron which cover a considerable area on the sides of the hills, and it has been proved, by shafts sunk into the beds, to be more than five feet in depth. I have not yet had the time to make an analysis of this ore, and, therefore, quote the one made by Prof. Richard Owen.*

Water,	-	-	-	-	-	-	8.0
Insoluble silicates,	-	-	-	-	-	-	16.0
Sesquioxide of iron,	-	-	-	-	-	-	69.5
Protoxide of iron,	-	-	-	-	-	-	trace.
Alumina,	-	-	-	-	-	-	3.0
Lime,	-	-	-	-	-	-	trace.
Magnesia, alkalies, and loss,	-	-	-	-	-	-	3.5
							100.0

From this analysis it will be seen that the ore contains 48.6 per cent. of iron, and 16. per cent. of silica. The experiment of smelting similar ores is about to be made by the blast furnace which has just been completed near Shoals, in Martin county, Indiana; and should it prove successful—and I have not the least doubt but that it will, especially if the native ore is mixed with a portion of the specular ores of Missouri—then there is no reason why this ore at Leopold should not be sought after, and blast furnaces be erected at the coal mines on the Ohio river for smelting it. This ore is not only found in the hills about Leopold, but may be seen at many other places in the county, some of which are indicated on the map which accompanies this report.

The conglomerate sandstone member will, in places, furnish good building stone. The Catholic church at Leopold, which is quite a handsome edifice, is built of stone from this series, and it gives promise of durability.

*Geological Reconnoissance of Indiana, 1859, page 183.

We may, then, in Perry county, enumerate as the economical minerals of this epoch—coal, iron ore, and building stone.

Coal Measures: In Perry county the rocks of this epoch are mostly massive sandstone, with a paucity of stonecoal and argillaceous shale, and they represent by far the greater portion of the entire measures of the State. The following section will represent the character of the rocks, and show the true place occupied by the "Main Cannelton Seam."

Section of the coal measures of Perry county, including the millstone grit, made from outcrops on the Ohio river between Rock Island and the mouth of Anderson creek:

SPACE.		Fr.	In.	
		30		Covered space.
57		12		Sandy shale.
		15		Limestone.
2.8		2	8	COAL K with six in. fire clay.
		2		Fire clay.
50.		48		Sandy shale.
.8			8	COAL I.
				Fire clay?
30.		30		Sandstone.
1.		1		COAL H and fire clay.

SECTION OF COAL MEASURES—Continued.

SPACE.		Ft.	In.	
90.		90		{ Shay sandstone and massive sandstone. Building stone.
1.6		1	6	COAL G. "Top coal."
		4		Fire clay used for pottery.
40.		36		Shale.
		5		COAL F. Fire clay.
53.		53		Shales and sandstone.
1.		1		COAL D?
		4		Fire clay.
		10		Shales.

SECTION OF COAL MEASURES—Continued.

SPACE.		FT.	IN.	
89.	.	40		Massive sandstone. Building stone.
		35		Thin bedded sandstone.
.6		0	6	COAL B.
		1		Fire clay.
71.		70		{ Conglomerate sandstone with pebbles.
2.6		2	6	COAL A.
2		2		Fire clay.
496.10	∴ Total.			{ Sandy shales belonging to the lower carboniferous.

It will be seen in the above column of the coal measures, that I give to the "Main Cannelton Coal," a position in the series which corresponds to that of the third block coal seam (F) at Brazil, in Clay county. It is 148 feet above the conglomerate sandstone at Cannelton, and there are two seams—B and D?—in the intervening space. The latter

seams are not known to be workable in this county, and the upper has been referred to D with some doubt, as there is, here, no evidence by which its equivalency can be determined, except that of the space between it and B (90 feet), which is sufficiently great to warrant the assumption that in it, a seam of coal may occur at some locality.

Mr. Joseph Lesley, Jr., determined the general dip of the strata at Cannelton with great care. He says:*

"5th. That the general dip of the strata is, as shown upon the accompanying map,† N. $76\frac{1}{2}^{\circ}$ W., its average fall being 33 feet to the mile.

"6th. That this dip is not regular, but in long low waves. These waves cause the leading peculiarity of this portion of the coal field, and also have been the cause of much perplexity and pecuniary loss to those who have undertaken to develop the resources of this district, for the main coal vein has always been found to become thin, and sometimes even to disappear upon the crest of these waves, thus reducing very much the area of the workable coal, and throwing it, so to speak, into pockets which are difficult to strike without a previous careful geological and topographical survey; the eye of the practical miner, even trained as it may be, not being so certain to detect these disturbances as a careful examination by compass and level.

"In the tunnel north of Cannelton, this thinning out of the coal vein can be plainly followed. A shaving off of the coal vein would express this better, * * * The whole four feet of coal, with its sulphur band, not being compressed into a streak only, but just the upper bench of coal disappears, then the sulphur band, and finally the lower bench of coal. * * * *

* Geological Reconnoissance of Indiana, by Prof. Richard Owen, State Geologist, p. 345.

†As no provision was made by the State to have this valuable topographical map published with the Report, the former State Geologist had it framed and hung up in the Geological Room. During the late war this room was used for other purposes, and the collection was boxed up and carried to the cellar, and in this way the map was lost.

"The strata decrease in thickness westward, even to entire absence, as in the coal of the shales overlying the main coal in the tunnel, where these measures are forty-six feet in thickness, whilst at the old Fulton banks, two miles to the westward, they have entirely disappeared, the roof of the coal being formed of the so-called 'Top Rock' mentioned in the section above. * * * *

"Besides these waves there is a fault running along the south side of Caney Fork of Deer Creek, and in a direction parallel to that of the general dip of the strata. At right angles to the fault, and running into it, is another, not so long, and showing itself on the east side of the valley of 'Hayden Meadow.' These faults are occasioned by an upthrow of the strata of the subcarboniferous limestone, which along Caney Fork form the bluffs along that stream and dip into the hills at an angle of 60° in a S. S. W. direction."

I am inclined to think that the appearance of the subcarboniferous limestone on Caney Fork is attributable to a strong wave in the strata, rather than to a fault. For here we have almost, if not quite, lost the whole of the sandstone member, which at the mouth of Deer Creek lies between the subcarboniferous limestone and the conglomerate, and which is, in places at least, one hundred feet thick. The cutting action, referred to by Mr. Lesley, must have, therefore, had full play here, previous to the deposition of the millstone grit.

At Rock Island mine, two and a half miles northeast of Cannelton, coal F is 147 feet above high water. Back of the Catholic church, at Cannelton, it is 80 feet, and at Fulton it is just at high water mark. At Tell City it is just below the bed of the Ohio river, and at the old pottery it has been reached by a shaft at a depth of forty feet below high water mark. On the opposite side of the river at the Reverdy mine, about half a mile above Hawsville, it is 185 feet above high water; at the Trabue mine, one-third of a mile below, it is 80 feet; at Hawsville 15 feet above, and at Haws' mine, one mile below town, it is 70 feet below high water. The difference of 65 feet in the level of coal F at Trabue's

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mine and the mine a few yards from it, in the east edge of Hawsville, and the difference of 70 feet between the mine in the west edge of town and Haws' mine, one mile below town, has generally been considered due to faults. But, here again, I must attribute these differences in level to the waves of the strata which Mr. Lesley speaks of, for no evidence of a break or the sliding of one stratum past another could be seen. My examinations, however, have not been as thorough as they should be, to fully settle this point, which was due partly to the fact that, on both occasions when I visited Perry county, I was in poor health and suffered, most of the time, from a slight fever; and I can not too fully express my obligations to Hon. Hamilton Smith and his accomplished wife for the attention received from them.

In 1856, while engaged on the Geological Survey of Kentucky, under the direction of the late Dr. D. D. Owen, I accompanied Prof. Leo Lesquereux on a trip through a portion of the coal field in western Kentucky, and I well remember our surprise on finding at Haws' mine near Hawsville, the whole of the coal measure strata from the "Anvil Rock" sandstone to the Conglomerate sandstone. The main Cannelton coal, F, is just below the level of the bed of the Ohio river at Haws' mine, now abandoned; as it is said that, in driving an entry in the direction of the river the water broke into the mine in such quantities as to prevent its being worked. The "head works" have been destroyed, the railroad track, to the river, has been taken up, and nothing remains now to mark the place of the mine, except the slope which is nearly filled with water. Everything, indeed, was so completely changed that great difficulty was experienced in finding the old land marks; but being aided in the search by Mr. Bunce, Superintendent of the Hancock mines, and Mr. Evans, mining engineer of the American Cannel Coal Company, we finally succeeded in finding the out-crop of the limestone coal K; and the other thin seams which lie above F, and in fact, to verify the section which was made here many years ago by Prof.

Lesquereux and myself. This section is here given for the sake of comparison with those seen in Perry county.

SECTION AT HAWS' MINE, KY.

SPACE.		Fr.	In.	
		?		Slope. Sandstone, "Anvil rock"? Sandy shale.
		6		Limestone.
2.6		2	6	{ COAL K with 12 inches of fire clay parting.
60		60		Sandstone and shale.
				COAL I.
80		80		Sandstone and shale.
1.6		1	6	COAL H.
80.		80		Sandstone.

SECTION AT HAWS' MINE—Continued.

SPACE.		FT.	IN.	
1		1		COAL G.
40		25		Hard bluish shale.
		15		Black bituminous shale.
4		4		COAL F. "Haws' coal."
				Fire clay.
219.	Total.			

The coal seam, four feet thick, at St. Meinrad's in the northern edge of Spencer County, is referable to F, and though not nearly so thick, this seam may be traced by numerous outcrops along Anderson Creek to Troy, where it is forty feet below high water mark, and has been reached by a shaft.

On Windy Creek, between Tell City and Troy, coal F is thirty inches thick, and it is mined by adits and by stripping at a number of places, and the coal is wagoned to market. But by far the most extensive mining operations in this county are carried on by the American Cannel Coal Company at Cannelton and at Rock Island mines, two and a half miles above. The seam here ranges from three to four and a half feet in thickness. They employ about 150 men and mine about eight thousand bushels of coal per day. Six banks are worked at Cannelton, three of which are reached by railroads leading to the river, and from the other three the coal is hauled in wagons.

The American Cannel Coal Company also owns the Hancock mines in Kentucky, four miles above Hawsville. All these mines are worked by adit levels, and the coal sold to steamboats is run to the river and dumped into barges. At

the Hancock mines, which are two miles from the river, a small locomotive is used to draw the coal. At Rock Island, the grade of the road to the river is such that the cars are run down by their own gravity, and the mules ride on a platform attached behind the car and draw the empty train back to the mine.

Clark Bros. lease their mines of the American Cannel Coal Company, and consume in their manufacturing operations about all the coal that is mined.

The Tell City Company have mines on their own property, from which they obtain a portion of the coal consumed in their extensive manufacturing establishments.

Mr. George Minto, a very intelligent mining engineer, who spent a great many years in the employ of Mr. Smith, and superintended the opening of most of the mines at Cannelton, sunk a shaft near the Old Pottery at the upper end of Troy, and at the depth of forty feet below the high water mark of the Ohio River, reached the Cannelton seam. Headworks were erected and mining operations commenced, but I was told that the mine could not be made to pay and it was finally abandoned. The shaft is now full of water, which precluded the possibility of seeing the coal; but I was informed that the seam was about three feet thick.

A most interesting section was obtained at this place, extending from the coal at the bottom of the Minto shaft to the top of a big hill just back of it. This shaft, it will be seen by reference to the map, is in the direction of the strike of the strata from Haw's mine, one mile below Hawsville, in Kentucky, and very nearly on the general strike of the strata as determined by Mr. Joseph Leslie's survey. And the sections at each place correspond as nearly as could be expected from measurements made with an aneroid barometer.

SECTION AT MINTO'S SHAFT.

SPACE.		FT.	IN.	
57.		5		Soil and clay.
		10		Loess?
		27		Covered and shale.
		15		Arenaceous limestone. Limestone.
1		1		COAL K.
		?		Fire clay.
50.		50		Sandy shale.
?		?		COAL I, thin.
				Fire clay.
		30		{ Sandy shale and heavy bedded sandstone.
		2		COAL H and fire clay.
		90		{ Schistose, massive and shaly sandstone.

SECTION AT MINTO'S SHAFT—Continued.

SPACE.		Ft.	In.	
90.				
1.6		1	6	COAL G. "Top coal."
		5		Fire clay used at potteries.
		10		Shale.
45.		30		Sandstone.
3		3		COAL F. Cannelton seam.
4		4		Fire clay.
				Low water in Ohio river.
283.6	Total.			

Corresponding sections may be seen in the hills on Windy Creek, northwest corner of section 20, township 6, range 3, and in a high hill just west of Cannelton. On Windy Creek, the limestone coal K, was at one time opened, and I learned from Mr. George Minto, Jr., that it was, here, a double seam:

SECTION ON WINDY CREEK.

SPACE.		Fr.	In.	
2.10			8	COAL.
			6	Fire clay.
		1	8	COAL.
		?		Fire clay.
	Total.			

From the sections already given, it will readily be seen that the limestone and coal K, about 210 feet above the main Cannelton coal F, furnishes as sure a guide to the place of the latter as the pebbly sandstone which is below it.

Two miles below Troy, at the "Mound" hill, in Spencer county, and on land owned by Dr. Gage, there are three seams of coal between low water and the top of the hill. These seams were all opened by John Stephens, of Rockport, and his brother A. Stephens. Commencing at low water, Mr. John Stevens put a bore down sixty feet to a seam of coal two and a-half feet thick, which is about the place of the Cannelton seam. Mr. Stephens made the space here, 181 feet between this seam and the limestone coal. I visited the locality with Mr. George Minto, and his son, and found the old openings had filled up. We saw plenty of large fragments of limestone scattered over the slope of the hill, but were unable to make sure of its exact place. As nearly as we could judge; however, I made its place, with the aneroid barometer, 130 feet above low water, where Mr. Stephens commenced his bore. Now this limestone and the subordinate coals, may be followed very nearly to Judge Ingle's mines at the city of Evansville, in Vanderburg county, and is, therefore, a very reliable guide to the seams which lie above and below it. The greatest depth of strata from this limestone to the conglomerate sandstone in Perry county, does not exceed 390 feet, and a slight wave in the strata between Grand View, in Spencer county, and the mouth of Cypress creek, in Warrick county, has brought to

the surface the "Martha Washington" rock at Rockport, which in my last Report was, I still think, correctly referred to the conglomerate sandstone.

To make sure of this, we need only carry our observations a little farther to find the crop of subcarboniferous limestone, a few miles south of Owensboro, Kentucky.

In order more fully to show the connection of the coal seams in Perry county, with those at Newburg, in Warrick county, I will give a section of the rocks at the latter place, made from out-crops above, and from the shaft as far down as seam I, and from thence down, from the record of a bore made for oil by R. R. Roberts. This bore is at the mouth of Cypress creek, a short distance up the river from the Newburg shafts, and commenced in the fire-clay at the bottom of seam I.

SECTION AT NEWBURG.

SPACE.		FR.	IN.	
15.		15		Sandstone and shale.
2.6		2	6	COAL X.
		1		Fire clay.
		8		Limestone.
				Place of Coal K.
		22		Sandstone and shale.
				Place of coal.
81.		50		Shale and sandstone.

SECTION AT NEWBURG—Continued.

SPACE.		Fr.	In.	
5.		5		COAL I. Main Newburg seam.
124.		3	6	Fire clay.
		2		Slate.
		1	6	White sandstone.
		22		Dark sandstone.
		58		Dark shale.
		7		Dark sandstone.
		30		Light sandstone.
1.		1		COAL F.
		1		Fire clay.
		50		White sandstone.
		17		Black shale.

SECTION AT NEWBURG—Continued.

SPACER.		FT.	IN.	
172.6		5		Gray slate.
		5		Reddish slate.
		5		Hard red rock.
		27.		Gray slate.
		2	6	White sandstone.
401.	Total.			

This section stops at about the top of the millstone grit and shows a wonderful thinning out of the lower coal seams. Seam K is also absent, but there is a seam just above the limestone which is generally considered its equivalent. This is, however, in my opinion an error, as I have seen a coal seam above and another below the limestone of this horizon at quite a number of localities, and we have only to go a few miles south-west of Newberg, at the first locks on Green river, in Kentucky, to find this phenomena; and here the main Newberg seam, five feet thick, is also found

at about the same distance, eighty feet below the limestone. In consideration of these facts I have referred the coal above the limestone at Newberg to X, since it corresponds in position to that seam seen below Maysville on White river, in Daviess county.*

Since writing the above I have been informed by Prof. Nutting that this coal has been found by a bore, between Washington and White river, in Daviess county, and is at this locality seven feet and ten inches thick. A company is now engaged in sinking a shaft for the purpose of mining it. Coal K is most generally a compound seam but when it attains too great a thickness, one and sometimes two subordinate seams unite with it, being separated merely by a parting of fire-clay.

By the aid of the section given above we may, with a considerable degree of certainty, correlate the coals of Indiana with those of Western Kentucky and Southern Illinois; and I shall venture to do so provisionally, commencing at the top with the sandstone, designated as the "Anvil Rock" sandstone in the Kentucky Reports. It can hardly be expected, however, from the nature of the basin in which the coals have been formed, that an equivalency can be established over so great an area, that will not require correction after more extended researches have been made. The coal strata do not, as was formerly supposed by many, spread over the entire field, but they lie rather in lenticular-shaped basins, formed either by an unequal resistance to elevating forces or by abrasions previous to the formation of the coal seams. We can not, therefore, determine over any very great area, the depth of which a shaft will have to be sunk in order to reach a given coal, by calculating the rate of its depression from the angle of its dip at the crop; nor can we expect to find the seam uniform in quality or thickness at all points.

Indeed, these are questions that require the most thorough research and study before they can be satisfactorily answered.

*See Geological Report of Indiana, 1870, page 34.

Section of coal seam in Kentucky from the "anvil rock" sandstone down to the conglomerate:

Feet.	In.	
35.	25	{ Sandstone; "Anvil Rock" of Ky. survey.
4	0 — 4 0 — 2	COAL X. Fire clay.
45.	0 — 25	Space.
	1 — 15	Limestone.
	1 — 3	Black bituminous shale.
10.	0 — 10	COAL K. (No. 11 of Ky. Rep.)
	3	Fire clay.
40.	37	Shale and sandstone.
2.6	0 — 2 1	COAL J. Fire clay.
61.	40 — 60	Shale and sandstone.
5.	0 — 5 4	COAL I. (No. 9 Ky. Rep.) Fire clay.
84.	40 — 80	Shale and sandstone.

SECTION OF COAL SEAM IN KENTUCKY—Continued.

SPACE.		FT.	IN.	
2.6		0 — 2	6	COAL H. Fire clay.
30		80—90		Sandstone and shale.
		0 — 3		COAL G. Fire clay.
		4		
44.		24—40		Shales and sandstone.
4.		4		COAL F. Fire clay.
		8		

SECTION OF COAL SEAM IN KENTUCKY—Continued.

SPAC.		Fr.	In.	
135.		60—130		Sandstone and shale.
4		2 — 4		COAL D. (Casey's coal.)
		4		Fire clay.
134.		80—130		Sandstone.
6			6	COAL E.
				Fire clay.
		70		Conglomerate sandstone.

SECTION OF COAL SEAM IN KENTUCKY—Continued.

SPACE.		Fr.	In.	
70.				
2.6		0 — 2	6	COAL A. Fire clay.
703.	Total.			

According to the above section it will be seen that the Cannelton coal F corresponds in position more nearly to the four feet seam at Shotwell's mine, near Caseyville, than it does to Casey's coal on Tradewater river in Kentucky, with which it has generally been correlated.

The Cannelton seam of coal does not belong to that variety of bituminous coal known as *cannel*, though there is sometimes a thin layer of cannel coal found on top of the seam. It is mainly a semi-caking coal and has a parting of sulphurous coal from a half inch to two inches thick and one foot from the top. The upper part has a dull vitreous lustre and breaks with a conchoidal fracture. The lower part is laminated and breaks into cubes. At the bottom of the mine there is from one to two and a half feet of slaty coal, and this rests on a thick bed of fireclay as shown in the section at page 93. The argillaceous shale forming the immediate roof of this seam contains a few stems of plants, and a fossil shell, *Lingula umbonata*.

An exhaustive analysis was made of coal from the different parts of the seam collected from the Rock Island mine, and the proximate analysis of samples from Clark's, Hick's and McMahon's mine, and also from the Hancock mines in Kentucky.

Analysis of coal from

ROCK ISLAND SEAM.

Upper twelve inches :

Coke, - - 54.50	{ Ash, white, - - - 2.00
	{ Fixed carbon, - - - 52.50
Volatile matter, 45.50	{ Water, - - - 4.50
	{ Gas, - - - 41.00
100.00	100.00

Coke puffed, vitreous, amorphous. Semi-caking coal, and burns with a large flame.

Analysis of a specimen from the sulphurous coal parting :

Coke, - - 69.50	{ Ash, red, - - - 11.00
	{ Fixed carbon, - - - 58.00
Volatile matter, 30.50	{ Water, - - - 3.00
	{ Gas, - - - 27.50
100.00	100.00

Coke not swollen, laminate, unchanged.

This parting contains a large portion of "clot," resembling mineral charcoal ; it is a non-caking and free burning coal, and has disseminated through it small pieces of pyrites.

Lower part of seam :

Coke, - - 58.50	{ Ash, white, - - - 8.50
	{ Fixed carbon, - - - 50.00
Volatile matter, 41.50	{ Water, - - - 4.50
	{ Gas, - - - 37.00
100.00	100.00

Coke much swollen, vitreous, amorphous. Caking coal, and burns with large flame.

Slaty coal at bottom of seam :

Coke, - - 62.00	{ Ash, lemon - - - 12.50
	{ Fixed carbon, - - - 49.50
Volatile matter, 38.00	{ Water, - - - 4.00
	{ Gas, - - - 34.00
100.00	100.00

Coke swollen, laminate, vitreous. Though containing a large amount of ash it will make a very good fuel for some purposes.

Analysis of a specimen of the so-called cannel coal, part of the

ROCK ISLAND SEAM :

Coke, - -	51.50	{ Ash, white, - -	6.00
		{ Fixed carbon, - -	45.50
Volatile matter, 48.50		{ Water, - -	6.50
		{ Gas, - -	42.00
	<u>100.00</u>		<u>100.00</u>

Coke slightly puffed, vitreous, laminate.

CANNELTON MINE AT CANNELTON.

Upper part :

Coke, - -	55.50	{ Ash, white, - -	4.00
		{ Fixed carbon, - -	51.50
Volatile matter, 44.50		{ Water, - -	3.50
		{ Gas, - -	41.00
	<u>100.00</u>		<u>100.00</u>

Coke much swollen, amorphous, lustreless.

Middle part :

Coke, - -	50.50	{ Ash, brown, - -	2.00
		{ Fixed carbon, - -	48.50
Volatile matter, 49.50		{ Water, - -	6.50
		{ Gas, - -	43.00
	<u>100.00</u>		<u>100.00</u>

Coke puffed, laminate, vitreous.

Bottom part :

Coke, - -	49.00	{ Ash, red, - -	3.50
		{ Fixed carbon, - -	45.50
Volatile matter, 51.00		{ Water, - -	5.00
		{ Gas, - -	46.00
	<u>100.00</u>		<u>100.00</u>

Coke puffed, laminate, lustreless.

CLARK BRO.'S MINES AT CANNELTON.

Upper part:

Coke,	-	-	50.50	{	Ash, white,	-	-	2.00
				{	Fixed carbon,	-	-	48.50
Volatile matter,			49.50	{	Water,	-	-	7.00
				{	Gas,	-	-	42.50
100.00								
				100.00				

Middle part :

Coke,	-	49.50	{	Ash, brown,	-	-	4.00
			{	Fixed carbon,	-	-	45.50
Volatile matter,		50.50	{	Water,	-	-	5.50
			{	Gas,	-	-	45.00
		100.00					100.00

Coke much puffed, vitreous, amorphous.

Bottom part :

Coke,	-	-	52.00	{	Ash, liver,	-	-	12.00
				{	Fixed carbon,	-	-	40.00
Volatile matter,			48.00	{	Water,	-	-	6.50
				{	Gas,	-	-	41.50
			100.00					100.00

Coke vitreous, not puffed, laminate.

Slaty coal beneath the seam :

Coke,	-	-	60.50	{	Ash, white,	-	-	24.00
				{	Fixed carbon,	-	-	36.50
Volatile matter,			39.50	{	Water,	-	-	8.50
				{	Gas,	-	-	31.00
			100.00					100.00

Coke slaty, laminate, unchanged.

HECK'S COAL NEAR CANNELTON.

Top of seam :

Coke,	-	-	55.50	{	Ash, blue,	-	-	6.00
				{	Fixed carbon,	-	-	49.50
Volatile matter,			44.50	{	Water,	-	-	4.50
				{	Gas,	-	-	40.00
			100.00					100.00

Coke puffed, vitreous, amorphous.

Bottom part of seam :

Coke, - - -	53.50	{ Ash, red, - - -	8.50
		{ Fixed carbon, - - -	45.00
Volatile matter, - - -	46.50	{ Water, - - -	3.50
		{ Gas, - - -	43.00
	100.00		100.00

Coke puffed, laminate, lustreless.

MCMAHON'S COAL.

Upper part :

Coke, - - -	52.50	{ Ash, blue, - - -	4.00
		{ Fixed carbon, - - -	48.50
Volatile matter, - - -	47.50	{ Water, - - -	6.00
		{ Gas, - - -	41.50
	100.00		100.00

Coke not swollen, lustreless, laminate.

Lower part :

Coke, - - -	56.00	{ Ash, brown, - - -	5.50
		{ Fixed carbon, - - -	50.50
Volatile matter, - - -	44.00	{ Water, - - -	4.50
		{ Gas, - - -	39.50
	100.00		100.00

Coke not swollen, lustreless, laminate.

An ultimate analysis was made of a specimen from the Rock Island coal taken from above the parting, and another, of a mixture of equal parts of Nos. 1, 2 and 3 of the proximate analysis :

	Ashes.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.
Upper part	9.	4.61	79.24	1.15	12.80
Mixture of Nos. 1, 2 and 3.....	9.5	4.15	75.10	.95	9.70

The theoretical calorific power of the coal from the upper part of this seam is:

$$.7924 \times 8080 = 6402.59 \text{ carbon calories.}$$

$$.0319 \times 34462 = 1110.33 \text{ hydrogen calories.}$$

$$6402.59 + 1110.33 = 7512.92 \text{ total heat units.}$$

The heat units of the coal being 7513, in round numbers, by dividing this by 100 the number of degrees between the freezing and the boiling point by Centigrade thermometer, we find 75.13 pounds as the quantity of water that a pound of coal will raise from the freezing to the boiling point, and by dividing the latter number by 5.5 we have 13.7 as the number of pounds of boiling water that one pound of coal will convert into steam.

From the elementary analysis of equal parts of the whole seam we find its calorific power in the same manner, thus:

$$7540 \times 8080 = 6092.32 \text{ carbon heat units.}$$

Available hydrogen, after deducting .0108, the amount combined with the oxygen as water:

$$.0337 \times 34462 = 1161.36 \text{ hydrogen heat units.}$$

$$6092.32 + 1161.36 = 7253.68 \text{ coal heat units.}$$

One pound of mixed coal will raise 72.53 pounds of water from freezing to the boiling point, or will convert 13. pounds of water from the boiling point into steam.

The late Professor Walter R. Johnson was employed by the United States Government to test the relative calorific value of a number of coals, both of this country and of Enrope, and among them the Cannelton coal. These tests, also, go to show that it has a high calorific power. The Cannelton coal is used in the manufacture of gas for lighting the cotton mill, but no account is kept of the quantity of gas made from a given quantity of coal; and I was, therefore, unable from this source to ascertain its yield. The quality of the gas, judged merely by the eye, on seeing it burn at the factory, is very good, and no great trouble is experienced in its manufacture.

Samples from the upper, middle and lower parts of the seam, and from the slaty coal, and a mixture of equal parts of all were tested in the laboratory for illuminating gas, and the result is given in the following table:

ROCK ISLAND COAL. PERRY COUNTY, INDIANA.	Coke.	Tar and Ammoniacal liquor.	Water.	Carbonic Acid and Sulph. Hyd.	Illuminating Gas by difference.	Cubic feet of Gas per lb. of Coal.
No. 1. Top of Seam	62.5	15.00	.25	.50	21.75	3.41
No. 2. Middle exclusive of the sulphurous band of seam.....	72.5	2.50	.....	.25	24.75	3.60
No. 3. Bottom of seam.....	62.5	15.00	.....	.....	22.50	2.62
No. 1, 2, 3. Average of seam.....	62.0	12.50	.25	.50	24.75	3.18
No. 4. Coal Rash, below bottom of seam	62.5	.....	5.00	.....	32.50	3.41

It will be borne in mind that the Youghiogeny coal analyzed for comparison gave 4.05 cubic feet of gas to the pound of coal, whereas, in practice at the Indianapolis Gas Works they obtain 4.34 cubic feet on an average; the ratio is as one to 1.07; calculated by this ratio the average of the seam, without the shaly coal at the bottom, will at the Gas Works, give 3.40 cubic feet of gas per pound of coal, or a short ton will yield 6800 cubic feet of illuminating gas. By selecting the best parts of the seam for gas the yield would be 3.74 cubic feet per pound or 7480 cubic feet from a ton of 2000 pounds.

The coal rash, or shaly coal, at the bottom of the seam will yield at the gas works 3.65 cubic feet to the pound, or 7200 cubic feet to the ton. This material, therefore, which is now thrown away as worthless, or left in the mine, is rich in gas, and from the low price at which it may be had, can be brought into competition with some of the coals which, though they yield more gas and a valuable coke, are much higher priced.

Some parts of the Cannelton seam will make an excellent coke. The value of the coke, from the average of the two

best portions of the seam for gas, as compared to the Youghiogheny coal, taking the latter as 100, will be—average coke from upper and middle parts of the seam, exclusive of the sulphurous parting; Coke 67.5—Ash 6.0=61.5 solid carbon. Solid carbon in the Youghiogheny 67.00; ratio of value 100 to 92.

In the Indiana Agricultural Report dated 1856, but not published until 1857, there is a communication bearing the latter date, from the pen of Hon. Hamilton Smith, giving a detailed and highly interesting account of the mining and cotton manufacturing interests of Cannelton at that time. Believing that it would be well to republish a portion of this communication, and on mentioning the subject to Mr. Smith, he very kindly gave me permission to publish such parts as I desired, and also to use the wood cuts which were formerly employed to illustrate it:

“The Company which I represent are now acting under the first charter granted by the Legislature of Indiana for the mining of coals. This was obtained in the year 1837, by a few New England capitalists, who immediately commenced operations under its very liberal provisions. With every promise of brilliant success, they expended a large amount of money in lands, (then perfectly wild,) buildings, drifts, shafts, boats, engineering, etc., and, when they were ready to deliver coals to the passing steamboats, they ascertained, to their cost, that the steamboat engineers were of opinion that such fuel would not make steam. After eight years of exertion, the Company were unable to extend their sales over two hundred thousand bushels a year, although they had the only coal mines opened below the Falls of the Ohio. Now, one of our packets requires a larger supply.

“The early efforts to introduce the use of these coals to markets below us, on the Ohio and Mississippi rivers, were attended with uninterrupted loss. Instead of dividends, the stockholders were subject to yearly assessments. The necessary expenditures exceeded all estimates, and no amount of capital seemed sufficient to establish the Company on a firm basis, and to make its stock yield an annual income.

After the operations of nearly twenty years, and an investment of something over six hundred thousand dollars, reckoning interest at six per cent., we are now just beginning to make both ends meet, and to rely with reasonable certainty on satisfactory dividends in the future. In the last few years our coal lessees have made very respectable profits on their business. There was no necessity for their purchase of more lands; they had no improvements to make, no railroads to build, no experiments to try, and no heavy taxes to pay on unproductive property."

* * * * *

"The value of our coals depends, of course, on their extent, accessibility and relative qualities. Reference has already been made to the difficulty of determining the first point from the few isolated facts already known. It is equally difficult now to determine the latter point. To be sure, many specimens from different localities have already been analyzed, and we can form an estimate of the character of the seams with somewhat more correctness than we could the character of a house from a specimen brick.

"Our Cannelton seam very closely resembles the 'Sheffield seam' in England, and near the city of Sheffield. That is separated in working into six varieties and for different uses. A portion of this seam produces a coking coal of great richness, and particularly valuable for metallurgical purposes. Other portions are very open burning, and are utterly unsuitable for even the ordinary uses of the blacksmith. The analysis of a specimen from either portion would give a very incorrect idea of the whole vein.

"The most extensive series of experiments ever made on American coals, were made by Professor W. R. Johnson, and his report to the United States Senate, for a time, fixed their relative values in public opinion. Unfortunately for us there was but one specimen sent to him from the Illinois coal measures, and that was a section of our Cannelton seam, including the top coal and parting sulphur band, which we never bring out of our mines. Of course the results did not fairly indicate the quality of our coals.

Under the disadvantageous trial, however, they proved equal to the best English varieties and, in some important qualities, were placed above the coals of Pennsylvania."

* * * * *

"The demand for our coal is increasing with great rapidity, and this year it is very far beyond our means of supply. When the changes are made below the falls of the Ohio, in the means of transit, that have already taken place above the falls; that is, when the steam tug and barges are substituted for the unwieldy flat boat, the coal depots from Cairo to the Balize will demand from us a very large quantity—perhaps twenty-five million of bushels a year—while the river cities and towns and sugar mills on the 'coast' may call for an equal quantity. It is quite possible that the time is not very distant when coals will be the largest item in our list of exports.

* * * * *

"We consider twelve bushels of our coals, properly used, as equivalent to a cord of the best beech wood for making steam, and ten bushels as good as a cord of ordinary cotton wood. The first is becoming more and more scarce on the banks of the Ohio, and its value increases in the same proportion, and either from the scarcity or other causes, the price of cottonwood on the Mississippi river seems to be steadily increasing. It now averages nearly or quite three dollars per cord between Cairo and New Orleans. This is equal to thirty cents per bushel for the coal, which, when we get fairly into the business and manage it with system and economy, we shall be able to supply, at less than an average of fifteen cents the bushel; and, besides, the mineral fuel requires less labor, is less dangerous, takes up less room, calls for fewer stoppages of the boat, and makes steam with more regularity than wood. Already the insurance offices are making a difference in their rates in favor of the boats using coal. As I write, the steamer Eclipse is lying before my door and taking on coal for her downward trip—over 9,000 bushels. This will about run her to New Orleans, and the saving in her fuel bill will

amount at least to \$1,250. The steamboats on the eastern waters commenced the use of coals about 1834. Now no other fuel is used by them, and such has been the diminution of their running expenses that their rates of passage and freight have been materially reduced, while the profits of running, even in competition with railroads, have been so satisfactory that larger and better boats have taken the places of the old. On our western rivers the same changes may be expected; changes that are as beneficial to our agricultural interests as to the merchant or the boat owner—more so indeed, as the value of surplus produce chiefly depends on the cost of taking it to market. If our farmers can be advised of the bearing of all the facts connected with this subject, they will aid us in obtaining a geological survey of the State, and by enabling us to get our coals at a cheaper rate, will secure cheaper freights for their surplus provisions and breadstuffs; and this, allow me to say, would be one of the very least benefits they would receive from such a movement. Show the home man of enterprise, and foreign capitalist, sure locations for developing with profit, the coal and iron, and other mineral resources of the State, and they will soon bring the mouths to the food, the consumer to the producer, and make a market on the land for the products of the land. Let it be understood that the Indiana farmers are now paying a sum for transit expenses on what they import, and on the exports they make to pay for these imports, greater than would suffice to manufacture their cloths and hardware, and the thousand foreign commodities required by their convenience and necessities, and they would soon cease to exchange the cheap and bulky products of home labor for the costly and compact products of foreign machinery and skill. No State in the world, taking into view her rich and level soil, water communications, equable climate and centrality of position, has greater mineral attractions than Indiana. Very few have as great. What we want is the certain knowledge of the position, purity and quantity of these minerals; and when other States are bringing their resources into notice,

by the investigations and publications of men of science, it can hardly be expected that foreign manufacturers and capitalists will take the cost and trouble of first explorations off our hands. I feel entirely confident that the taxables of the county of Perry, would now be ten, if not twenty fold, greater than they are now, had Dr. Owen's geological reconnoissance of 1837 been continued and enlarged into a systematic and thorough survey. Other counties would have witnessed the same results.

"Since 1848, our coal has attracted a cash capital of nearly a million of dollars, and a population of about four thousand. The pay rolls of our mines and cotton mills now reach two hundred and fifty thousand dollars a year for labor alone. Could we have had an official endorsement of the facts brought before the public by us, and thereby avoided the imputation of interested statements, we might have made far more successful draughts on foreign capital and skill. Our experiment of manufacturing cotton, in a first class western mill, has been, as a whole, eminently successful. The increase of this branch of industry here and at other favorable points on the coal sections of the State, is as certain as the fact that, in all the older countries, manufacturing facilities, far inferior to ours, have invariably attracted a dense and thrifty manufacturing population. The question is merely one of time. I have not the present leisure to discuss this, or to answer your second inquiry more fully than to say that our cotton goods are equal to any of their class made elsewhere; that our labor is, to say the least, as abundant, efficient and reliable as can be found; that we have an advantage in the convenience, quality and cheapness of our material, over the New England mills, and on the fixed capital employed, of about ten per cent. per annum; that our subsistence, power and heat are cheaper than can be obtained in any manufacturing district; and that we need only a full set of cotton mills and the home supplies of auxiliary work shops, which such a set of mills would employ, to show a less cost of spinning

and weaving the great staple of our country, than can be shown in any cotton mills in Europe or America.

"To give greater usefulness to this paper, I add to the foregoing general remarks a few of the details of finding, opening and working our Indiana coal seams. There is very little in foreign and eastern books on collieries and coal mines that is of practical use to those whose sole object is to find our coal with the least trouble, and then to work it at the least cost. In the following observations and diagrams, my design is to communicate such facts as our experience here has shown to be most important to those already engaged in or about entering upon the same business."

* * * * *

"Examine all the out-crops in the vicinity, and take their levels and distances with accuracy. If the facts spread on the map indicate uniformity of the thickness, 'dip,' inferior clays and superior slates, and sand rock strata, commence the entry at the lowest convenient level, being careful to make the mouth of the entry so firm as to resist the land slips above and on the sides. Too much care can not be well taken in this respect. The entry should be timbered thoroughly until the stratum of superincumbent slate or stone has a thickness of eight or ten feet. It should be driven double, about eight feet wide at the bottom and seven feet at the top, and about five feet in height; the coal pillar, separating its two parts, should be from ten to eighteen feet in width. The direction, of course, should be up the incline, and with the slip of the coal. By the way, on this side of the coal field, its face and level is nearly coincident with the magnetic meridian, and the dip at right angles west. To secure the easiest drainage and ventilation, (for the choke and fire damp, like water, flow down hill,) the entries and rooms should run eastwardly, or rather the main entries should run directly east, and the rooms on either side should run from 5° to 10° east of north and south, which usually will give sufficient drainage. Where it is impracticable to get at the coal from the west, the

double entry should be driven to the lowest attainable level in the mine, and then at right angles, forming what is called a 'sump' entry for purposes for drainage, and to which the pipes of the force or lift pump should extend. Sometimes it will be most economical to sink a shaft or well at this point, and pump up the water perpendicularly. The drainage arrangement being completed, the rooms should be commenced at the farthest point of the entry, at a width of eight feet, and widening out to five or six yards, depending on the character of the roof and the hardness of the coal. These rooms should be worked eighty yards, and with great regularity. Then another entry, and so on. The width of the pillars should be the same as the width of the rooms. There are two objects in commencing the working in the farthest end of the mine. First the drainage and ventilation is easier, and next, the pillar coal should be taken out as soon as practicable. If it stands over two years, there is very considerable cost in clearing away the fallen fragments of the roof, and, besides, the rooms soon become choked up and filled with water and foul air. Unless the miners (who work by the piece, and are very much in the habit of changing their localities,) are watched very closely, they will work the rooms irregularly, and most to their immediate advantage. By neglect of this care, mines are often absolutely ruined within the first year or two. The proprietor should have a carefully prepared map of the mine, and have it corrected every month or two by actual measurements. As we have no practical work on this subject, and as the English works are not always to be obtained, I give here a diagram of a mine properly laid off.

In our Western mines, the main entry has been usually made sufficiently high for an ordinary sized mule, the dwarf mules only being worked in drawing the single cars through the side entries and rooms. When the seam is less than three and one-half feet thick, the practice is to take up bottom to give sufficient height. The English practice is worth following here. Instead of making depth, which in

HORIZONTAL SECTION

OF A

COAL MINE.

The white spaces represent coal worked.

The black spaces represent the remaining coal.

Scale—100 feet to 1 inch.

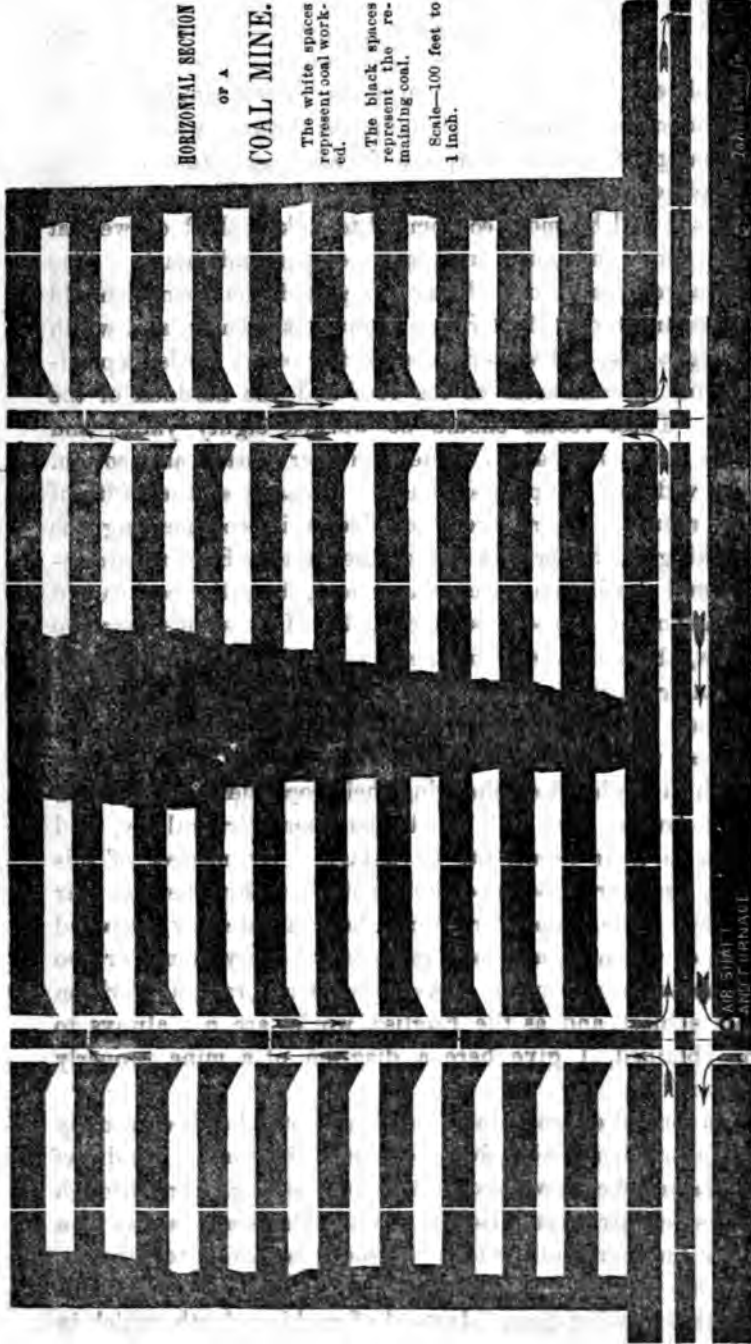
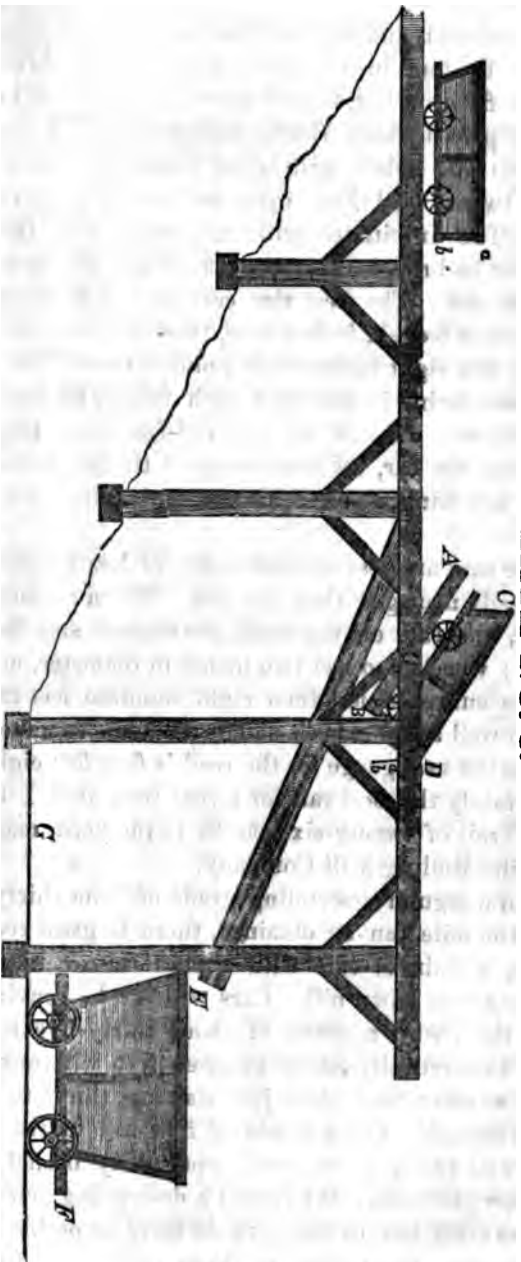


PLATE No. 2. [for description see pages 124 and 125.]

PLATE NO. 3.



[For description see page 128.]

most fire clays is difficult, they use low iron cars; and instead of three by four inch wooden rail, they lay down a road with the flat iron bar, turned up on its edge, and keyed into sleepers placed about thirty inches apart. These can be taken up and relaid with great readiness, and a boy can push a twenty bushel car upon them with great ease to the entry. The uninitiated will understand that these small cars must be brought into the rooms and within easy reach of the miner. The best size cars for our three to five feet seams is five feet six inches long, three feet four inches wide, and one foot eight inches high, holding twenty bushels; the wheels ten inches in diameter, with flanges of one and one-half inches. Instead of the old-fashioned trap at the bottom of the car, we have adopted the tail-board, swinging on top hinges and tipped on a cradle. See diagram No. 3.

These cars are less expensive, are of less weight, and are more easily managed than the old. When an outside road is used, the cars of the most convenient size hold sixty bushels; wheels two feet two inches in diameter, and, if the road has curves of less than eight hundred feet radius, the axles as well as the wheels should be made so as to revolve. Perhaps the best gauge for the road is four feet eight inches, and certainly the best rail for a coal road that I have seen is the T rail of twenty-six pounds to the yard, made by the Louisville Rolling Mill Company.

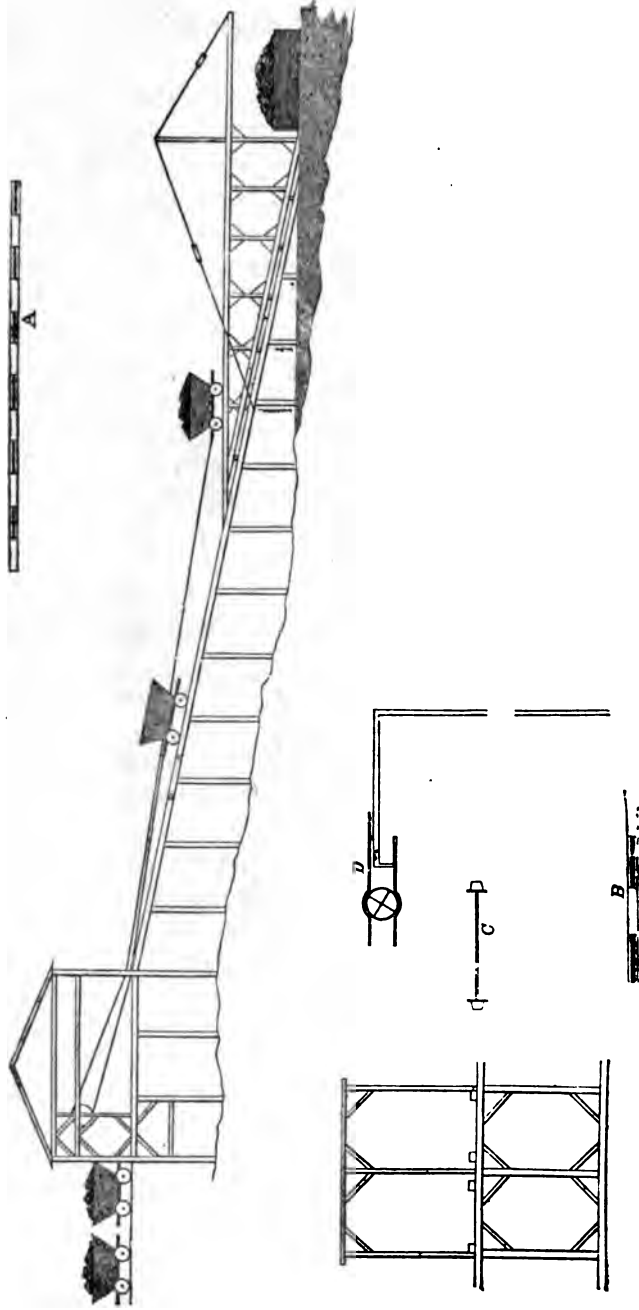
When a regular descending grade of from thirty to sixty feet to the mile can be obtained, there is great economy in running a train of cars with a platform car, in which the mules can ride down hill. Cars will run by gravitation, on a good road, with a grade of about thirty-five feet to the mile. Theoretically, about nineteen feet will answer; but in cold weather, and when just starting, thirty to forty feet is little enough. On a grade of fifty feet to the mile, two mules will easily draw four empty sixty bushel cars and their own platform. We regard a descending grade of from thirty to sixty feet to the mile as more favorable than any other, because the mules can do so much more work when

pulling but in one way. Probably mule power is cheaper than steam power, whatever may be the extent of the delivery, when the road is not over two miles in length. It is often an economical arrangement to use planes to get from a lower to a higher elevation, the empty car being drawn up by loaded cars, by use of drum, rope and brake. An inclination of one foot in eight, or $7^{\circ} 11'$ is sufficient. The form of the track on the plane, with a self-acting switch, is given in plate number 4. Thirty thousand bushels can be run over such a plane, of moderate length, in twelve hours. When a plane is necessary at the mine, it is better to draw up the large cars than to let down the bank cars; and a turn-table should not be used, when the road can be connected with the foot of the plane by a curve of over 40° . When coal is to be delivered into boats, and on a river subject to rapid rise and fall, we find a plane and slide, with a double track, decidedly the most convenient and economical arrangement. This, I believe, originated here, and is still peculiar to the Ohio river mines in this coal field.

It is equally appropriate to the Wabash and White rivers, and I give the form in plate No. 5. The best grade is one inch in five. All these fixtures at the river should be made with great strength and accuracy. With a proper drum-house, they will cost from \$2,500 to \$3,000, and, in the long run, the best are the cheapest. The saving of the labor of a single man, or the damage sustained by the running off of a few cars, is more than equivalent to the interest and decay of a well-made work. A section of the double road and turnouts at the drum-house is given in Fig. 2, plate 4. Before leaving this branch of the subject, I may state that iron car bodies are not as good as those made of oak covered with sheet iron, where the coal, falling from the chute will strike. The outside cars should be discharged by a trap at the bottom.

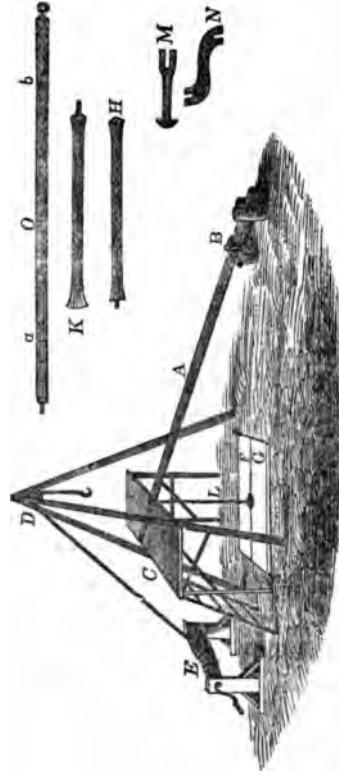
When the probabilities of finding a good coal seam at a depth of less than a hundred feet approach certainty, shaft-

PLATE NO. 5.



[For description see page 128.]

PLATE NO. 6.



[For description see page 136.]

ing is far preferable to boring.* If successful, the cost of boring is saved, and besides, the evidence obtained by boring is rarely satisfactory. When there are no such strong probabilities, boring, as a far cheaper process, should be resorted to. Plate No. 6 shows the manner in which this is done, and the character of the tools used. The screws can be obtained at any of the large cities, and any country blacksmith can fit up the whole apparatus.

The English use iron rods, in four feet sections; in this country, a few short sections, say one-half, one, two and three feet, and the others eighteen feet, with ash rods carefully fastened into iron sockets, are preferred from their cheapness and lightness. A little practice will enable ordinary laborers to manage this apparatus. For the first fifty or sixty feet, it is easiest to bore by hand; at a lower depth, use the spring pole. Unless a chisel should chance to break, no great skill is demanded in the mere drilling and taking up of the debris. Portions of this should be carefully examined whenever the sound or feel of the rod indicates a change of strata at its bottom. Here is the difficulty, and one which very few understand. Any intelligent person, who will take the trouble to pound up the different kinds of sand rocks, slates and coal, and examine the particles separately with a magnifying glass, can very nearly approximate the truth by making the same examination of the particles brought up by the pump used with the rods. I would advise such to trust to their own care and judgment, instead of relying on any common miner. There are plenty of these miners who understand the use of the rods, and who will keep on boring as long as they get well paid. With such a workman, a constant personal inspection may answer. Where there is any doubt of the character of the particles brought up, it would be well to send small parcels to some experienced geologist. This can be done by mail with little

* In making experimental shafts, say four feet square, the air may be kept pure by the use of a blacksmith's bellows, and gum elastic hose attached to its nozzle.

trouble. Of course these particles should be well dried before examination. There can be no mistake in distinguishing coal or coal shale from the rock. It is, however, difficult to distinguish the coal from the shale lying immediately upon the coal. Yet a close inspection with a good glass will enable one to see the sharp and glossy fracture of coal even in very fine pieces. Another obvious test is combustion; although some of the coal seams have a semi-combustion shale, often six or eight inches thick, immediately above the coal. It requires great experience to distinguish the true coal slate. Thousands of dollars have been expended in this vicinity in boring and shafting through a "bastard slate," that an expert would have abandoned as soon as struck. It lies here from fifteen to sixty-five feet under our main coal.

Whenever the shaft is determined on, place it as near as convenience will allow over the greatest depression of the coal in the property to be worked, so that the miners can communicate at the bottom of the grade.

All our coals are worked by the excavation of a few inches of the bottom of the seam or in the "bearing in slate," which is almost uniformly found under the Cannelton seam of a thickness of several inches between the coal and the fire clay. The miner "bears in" as far as he can reach with the pick, say three to four feet. The importance of keeping this space free from water is evident, and the consequent expediency of working up the incline."

* * * * *

When the coal is won by blasting, the powder is generally furnished by the employer. The sharpening of tools is done by the employer at a charge of about seventy-five cents per month. The mule drivers in the bank get two and a half cents per load when the distance is not over five hundred yards. The taking up bottom is usually paid by the piece, and runs from twelve and a half to twenty-five cents per lineal yard. Opening entries, as far as props are necessary, about \$3.25 the lineal yard, the proprietors furnishing the props and taking the coal. The posts can be

furnished when the timber is convenient at \$6 per hundred; the puncheons, with which the top and sides are protected, are worth \$1.25 per hundred, making the whole cost per lineal yard \$4. Beyond the timbers the cost ranges from \$2.75 to \$3 per yard. Wages paid by the day and month will average about this:

For shafting and for purposes of ventilation or proving coal we usually pay \$1 per foot for first thirty feet, increasing fifty cents every ten feet.* The price paid for mining is enormously high, when we regard the character of the labor. In one of our mines, leased to Messrs. D. Newcomb & Co., the pay roll of last month gave an average to miners of \$49; to the bank mule drivers, who are boys of ten to fifteen years of age, \$21; and to outside hands and road layers, \$35. Perhaps one-third of the miners were never in a coal mine before last year, and some had been in but a few weeks. The best miners made from \$60 to \$80. Now this work is not more laborious, not more unhealthy and not as dangerous as wood chopping. Our miners have been remarkable for their good health, and there has been but one fatal casualty among them here for twenty years, as the result of this employment. This was caused by the falling down of a part of the roof, and the miner was warned by the Superintendent of the danger, and directed to remove it. His death, therefore, was the result of his own culpable neglect. Until recently, most of the miners on the lower Ohio, have come from the English and Welsh coal mines;

* COST OF CARS, ETC.

Sixty bushel cars.....	each	\$150 00
Twenty bushel cars (wood bodies).....	each	25 00
Twenty bushel cars, iron bodies 150 lbs. sheet.....	each	27 00
Picks, weight 1½ lbs., sell to miners at.....		75
Rakes, weight 6 lbs., sell to miners at.....		1 25
Wedges, weight 2½ lbs., sell to miners at.....		25
Sledges, weight 8 lbs., sell to miners at.....		1 00
Shovels, No. 2, sell to miners at.....		1 25
Cost at Pittsburgh \$9 per dozen.		
Bank mules, from 3 feet 7 to 4 feet 2 inches.....		\$55 00
Cost of breaking.....		10 00
		65 00

have generally been indisposed to settle permanently at any place, or to work at any other employment, when the mines from any cause were closed. The irregularity in the demand also had a tendency, not only to keep them unsettled, but gave them time and opportunity to combine against employers and to keep up prices. Within a few years, however, we have received a large number of emigrants from the mineral districts on the Rhine, whose first object is a freehold. They are making excellent miners and thrifty citizens; with scarcely any exception, they invest their first savings in the purchase and improvement of a lot, which is generally selected in the vicinity of the town, and sufficiently large for a garden and small vineyard. They seem to comprehend fully the mutual interests that exist between themselves and their employers, and in the dull season they are willing to work at a price which the employer can afford to pay. They are, perhaps, the only miners who will readily take advantage of a double field of labor.

The superabundance of miners at the German collieries is indicated by the very low prices paid at them—say from eighteen to twenty cents a ton of 2,240 pounds for digging, and about one and thirty-five one-hundredths for coal at mouth of pit. These collieries are worked far beneath the “grass,” and the coal is inferior to and harder than ours. At the Welsh and English collieries, the cost of mining is much lower than here; a thirty inch seam is often worked at less than three-tenths of a cent per bushel.

Taking into consideration the freedom of our mines from foul air and explosive gas, there would seem to be no good reason why our prices should be maintained whenever and wherever we obtain a regular demand for our coals. This demand is increasing with great rapidity, and this year it is very far beyond our means of supply. When the same changes are made below the Falls of the Ohio in the means of transit that have already taken place above the Falls; that is, when the steam tug and barges are substituted for the unwieldy flat boat, the coal depots from Cairo to the

Balize will demand from us a very large quantity, perhaps 25,000,000.*

DESCRIPTION OF PLATE NO. 6.

FOR PLATE, SEE PAGE 131.

A is a stout spring pole, fastened down at the thick end, and resting upon the prop *B*. Near the small end a small stave is passed through, affording a hand-hold to two men standing on the platform, *C*. *D* is a triangle erected over the platform, and also exactly over the spot for boring, sustaining a pully-block and rope, the latter attached to the windlass, *E*. *F G* is a flooring of planks, with a hole in the center through which the rods work. These rods, *H R*, are of iron, four feet long, an inch in diameter, and tapped with good screws at their ends, which are somewhat swelling out to give strength. The lowermost rod, which operates upon the rock or other stratum, is a sort of chisel, *K*; the uppermost terminates in a stout ring, through which passes the cross-piece, *L*, and which, in working, is taken hold of

*The cost of towage with capacity of barges, tug, etc., was estimated at the last meeting of the Coal Association of the lower Ohio, thus :

FIXED CAPITAL. —Boat of six hundred tons, drawing light, four and a half feet, six boilers, twenty-five inches cylinder, fourteen feet stroke.....		\$30,000
Twenty-four barges, holding 11,000 bushels each, at \$1,500...	36,000	
		\$66,000
Interest, insurance and deterioration.....	22,400	
Cost of crew, provisions and oil per month \$1,470, eight months season.....	11,360	
Six hundred bushels coal per day, two hundred and forty days, at seven cents.....	10,080	
Twelve trips of 88,000 bushels each, at seven cents.....	73,920	
Insurance on coal, ten per cent., (too large by half).....	7,392	
Contingencies.....	1,000	
Cost of 1,056,000 bushels in New Orleans.....	\$126,552	

Or a fraction under thirty cents the barrel of two and a half bushels; or 4-1,000 cent per mile transit cost.

by two men; it is also suspended to the springing pole by a chain. One of the rods is formed at the end with a shell like a common augur, and is used for the purpose of bringing up portions of the detritus formed by the action of the chisel. The mode of operation is as follows: One or more rods being pushed into the ground through the hole in the planks, the two men on the stage taking hold of the cross stave at the end of the springing pole, work it up and down, while the two men below, by means of the cross, simultaneously heave and depress the suspended rod, walking at the same time slowly round the hole—by these combined operations making way through whatever substance may come in contact with the chisel on the lower rod. When it is wished to ascertain the stratum they are passing through, or to clear the hole of the loose matter at the bottom, the rods are withdrawn by means of the tackle described above, the chisel is unscrewed and replaced by the shell, when they are again lowered to extract the detritus for examination and clearance. *M* is the spanner used for screwing and unscrewing the rods, and *N* an iron fork, the prongs of which are placed across the rod below the swell, and in contact with the floor, to prevent the lower series from slipping down while the upper one is being screwed off or on. *O* is an ash rod, eighteen feet long, with male and female screws on iron sockets, *d a, b c*, strongly bolted to the wood. This rod is found lighter and better in deep borings than the short iron rod, *H*. Where water is used in boring, the shell above described is replaced by a hollow copper cylinder, a little less in diameter than the chisel, from two to four feet long, open at the top, with an ordinary pump valve near the bottom. As the cylinder is put down, the valve is forced open and the tube filled. As the cylinder is withdrawn, the valve is closed by the pressure above, retaining the matter forced in by the descent.

Tertiary: There is near the top of the hills at Cannelton, and at Tell City, a deposit of small rounded gravel and ferruginous, sandy clay, that resembles very much a deposit of similar character which is seen on the banks of the Ohio river, in McCracken county, Kentucky, and near Elizabeth, in Massac county, Illinois. At the latter locality it is cemented into a compact pudding stone, and forms the rocky obstruction across the Ohio river, known as the Grand Chain. Here it is, without doubt, correctly referred to the tertiary, as it is associated with the strata which contains well known fossils that characterize that age. But in Perry county, the deposit is quite limited in area, and has furnished so far no evidence beyond the mere lithological resemblance to the above, that will warrant its assignment to a period more remote than the drift. In this county it rests on carboniferous shale and where seen is covered with clay and soil.

Quaternary: The brown marly clay characteristic of this epoch is seen on the top of the high hill at the Pottery Company's property, just above Troy; and it also makes its appearance on the Mound hill, below the mouth of Indian creek, in the edge of Spencer county. It varies from ten to fifteen feet in depth, and though often rich in fossil shells, I was unable to find any in it here.

Building Stone: No county in the State is better supplied with building stone that can be so conveniently quarried and sent to market. The great cliff of sandstone over two hundred feet in high which faces the Ohio river and reaches from Cannelton to Rock Island, a distance of more than two miles, has, in the series of layers of which it is formed, two massive beds that furnish excellent building stone; these beds are, in places, from twenty to forty feet thick without a seam, and blocks may be quarried of any required size. The layer just above the "top coal," seam G, is said to furnish the best stone, and it is from this layer that the stone was obtained which was used in building the cotton

mill and the Catholic church at Cannelton. These buildings are handsome structures and of elegant design. The color of the stone is light brown and when first quarried it is quite soft and easy to work; but hardens after being exposed to the air. The lower quarry is very similar in structure to the upper layer, but is more liable to contain imperfections. The color is also about the same as that of the upper seam. The Cannelton quarries furnished the stone used in the construction of the locks on Green river in Kentucky; for the abutments and piers of the Elizabethtown and Paducah Railroad bridge over the Tennessee river; for the railroad bridge over the Cumberland river; and for the railroad bridge over the Wabash river at the Grand Chain; as well as for the construction of the Government Navy Yard at Memphis, the locks of the canal at Louisville, and many other important works; and under all conditions it has proved to be a strong and durable stone.

Lime: There is an abundance of limestone in the eastern part of the county suitable for making lime, but I believe that no attention has been paid to its manufacture.

Oil Wells: During the great oil excitement in 1865-6 quite a number of wells were bored in the northern part of this county, on the waters of Anderson creek and Oil creek. These wells were generally carried to the depth of 700 feet, and in one or two of them there was found a little oil and gas, but not sufficient to be of the least value. The others were without any results whatever, and the territories which had been leased for this purpose, after the expenditure of large sums of money, were abandoned.

I have not, so far, been able to get any reliable account of the strata through which these wells passed. If records were kept they have been lost or taken away by the parties who superintended the work. Though it is extremely doubtful if oil in paying quantities, can be found in the county, still, I do not believe that these wells were carried to a sufficient depth to reach the Corniferous and Niagara

limestones from whence the oil is obtained in the Terre Haute well.

Manufactures: I have already written of the numerous extensive manufacturing establishments in this county, and I desire here merely to call attention to the advantages which it offers for the manufacture of iron. Though the Cannelton coal may not quite answer in the raw state for the manufacture of iron, it will make a very good coke, and by mixing the two together a fuel is obtained that is in every way suited to the blast furnace. Iron ore may be brought in barges from Missouri and the Cumberland river ore banks at a small cost for transportation, and the large deposits of ore which exist at and in the vicinity of Leopold, though rather silicious to be worked alone, may serve an admirable purpose to mix with the more refractory specular ores of Missouri. The blast furnaces in Newport and Covington, Kentucky, and those of Pittsburg, Pennsylvania, get a large portion of their supply of ores either by way of the river or by rail from Missouri; and it is reasonable to suppose, therefore, that the cost of producing a ton of pig iron in Perry county may be considerably lessened by the saving on freight alone.

Agriculture: By far the greater portion of Perry county is broken and uninviting for agricultural pursuits; but its rugged parts are being rapidly settled up by an industrious class of Germans and French, who, by careful tillage, obtain fine crops of corn, barley, wheat, oats and grass; clover grows well on the hill lands, which are also well adapted to the growth of orchard fruits. One of the largest and best orchards in this part of the State is situated six miles above Cannelton, and was planted by Hon. John C. Shoemaker, and lately sold by him to Charles G. French of Indianapolis. This orchard has for its rocky foundation the conglomerate sandstone which forms a steep cliff about two hundred feet above high water, where the farm fronts on the Ohio river. It is well stocked with all the best varieties of apples and peaches, and on the property there is also a fine

vineyard. Grapes seem to do well wherever they have been tried in the county when the vines are not enfeebled by excessive pruning.

The bottom lands, especially along the river, are among the finest farming lands in the State. In places, as at Tobin's Point, the bottom is broad and very extensive; indeed, it here covers the entire point, which is formed by a great bend in the river.

The soil of the bottom land is, for the most part, a sandy loam, and is particularly suited to grow corn, grass, potatoes, turnips and cabbage, though all the cereals do well. Hon. James Hardin raised last year, on his farm near Rome, two hundred and fifty bushels of potatoes to the acre, but one hundred and twenty-five bushels is considered an average crop. About 25,000 bushels are produced annually in Tobin township alone. In Union township about 100 acres are planted in cabbage, for market, and 3,000 heads are the usual number raised per acre. They sell readily at three cents per head and are a profitable and easily raised crop. The yield of grass will average one and a half tons to the acre, and the yield of corn about fifty bushels to the acre.

Tobacco grows well on either the hill or bottom lands, but there is very little attention given to its culture.

Timber: The large forest trees that were within easy reach of the river have mostly been cut down and converted into lumber, but in the interior, and especially in the northern part of the county, there are tracts of land with scarcely a tree destroyed. The trees are very large and fine and are of every variety usually found in this latitude; those most numerous and suitable for lumber are Poplar, Black Walnut, White Walnut, Ash, Oak, Cherry, Beech and Sycamore. In addition to those most useful for lumber, there are large Hickories, Elm, Hackberry, Sassafras, Persimmon and occasionally Buckeye trees.

Antiquities: Mention has already been made of the deep mortar-like holes found in the rock houses, and of the fact

that these sheltered places were used by the aborigines as sepulchres for the dead, and I desire under this head to merely call attention to some other matters of interest connected with prehistoric man :

One mile above Rome, on Mr. Reynolds' farm, and on the second bottom of the Ohio river, which is here about ten feet above the overflow of that stream, there is an aboriginal shell heap which has been plowed over for many years and now corresponds to the general level of the field.

This heap of refuse from the kitchens of the aborigines, is mainly composed of the shells of the fresh water malusca belonging to the family *unionidæ*. The shells are broken and in such a state of decomposition that, on being pressed between the fingers, they readily crumble into powder. Their decomposition in this place has been hastened by frequent disturbance in plowing, and the beneficial influence of the lime and phosphorus which they furnish to the soil, is quite manifest in the increased yield of this part of the field. The depth and area of this shell heap, or heaps— for there may have been a row of them—could not be determined on account of its disturbed condition, but there is reason to believe that it extended at least fifty yards along the low ridge. No bones of animals nor bone implements were seen, but just at the rear of the shell bed, with the assistance of Mr. Conner, I succeeded in finding several slightly broken stone axes, some stone pestles or grinder, and a number of flint arrow-heads and flint flakes, and he informed me that great quantities of arrow and spear-heads and other stone implements have been, from time to time, picked up on different parts of the field.

I heard of no mounds in this county, but there is a very large one in the edge of Spencer county, two miles below Troy. It is on the top of a high hill, is fifteen feet in height, oval in shape; and about thirty feet in its greater diameter. The decayed stump of an oak tree which grew on its side measured two feet in diameter. A hole had been dug in the top of the mound, but Dr. Gage, who owns the land, informed me that no relics had been found. From the top

of the mound there is a commanding view for several miles both up and down the river.

A great many highly interesting stone relics have been found in this county, the most important of which were sent by Hon. Hamilton Smith, to the Smithsonian Institution. Master Rudd Smith gave me a fine specimen of stone pestle or grinder that is made of green stone and worked quite smooth; and a very large and deep basin made of brown sandstone was obtained from the Hon. John C. Shoemaker, Auditor of State, which was found in a valley between Cannelton and Tell City. This basin is twelve inches outside diameter at the top, interior diameter nine inches, depth three inches, height five and one-fourth inches, diameter of bottom which projects three-fourths of an inch below the bowl, six and one-half inches. It is symmetrical in form and as smooth on both inside and outside as if it had been fashioned in a lathe. On opposite sides it has ears or projections by which to lift it.

Conclusion: Before closing these remarks on Perry county, I desire to return my thanks to its citizens generally for the courteous treatment which has been extended to me on every hand; and for the great interest manifested by them in the survey.

In addition to the persons whose special favors have already been mentioned in the body of the report, I desire to acknowledge my obligations to George Minto & Son, mining engineers; Aaron Evans, mining engineer; Roan Clark, William Clark, James R. Bence, Col. Hanning, Judge C. H. Mason, editor of the Cannelton Reporter; S. B. Hatfield, editor of the Examiner; John Peters, Recorder, and Samuel Platt, Esq., all of Cannelton. Also, to Samuel K. Conner and Dr. Gage, of Troy; W. B. Reynolds, Hon. James Hardin and John T. Conner, of Rome; Henry Delville, Andrew Loffenot and Rev. B. Unversaght, of Leopold; Abraham Lusher and A. Howe, of Lusher P. O.; and to S. Whitten, Mr. Steiner and Mathew Combs, of Tell City.

GEOLOGICAL NOTES
OF A TRIP
FROM NEW ALBANY, IN FLOYD COUNTY
TO
HARRISON AND CRAWFORD COUNTIES.

It is twenty miles over a good turnpike road from New Albany to Corydon, in Harrison county. The "black slate" which crops out along the river bank at New Albany was bored by the late Dr. Clapp, and found to be one hundred and ten feet thick. It is the lowest rock seen along the route, and is soon carried beneath the surface by the westerly dip of the strata; and is succeeded by a greenish marly shale which carries from one to three bands of good limonite iron ore, formed by contiguous flattened masses two to four inches thick. From the weathering away of the soft shales in which it was embedded, this ore has fallen down, and vast quantities are seen in the ravines, and scattered over the sides of the hills. Just before reaching Edwardsville, six miles from New Albany, we lose sight of the knob shale and sandstone, and attain an altitude of four hundred to five hundred feet above the "black shale." From this point to

Corydon the road is over the cherty subcarboniferous limestone. The soil on the high ridges is reddish brown, and the subsoil a dark red clay, containing a large percentage of iron. These ridges are well adapted for growing all kinds of fruit, and the crop this year is large and the quality of the fruit very fine. Corydon was the second capital of the Territory of Indiana, and the first capital of the State. It is situated near the center of Harrison county, at the junction of Little and Big Indian creeks, and is a beautiful town. Its dwellings are neat and surrounded with yards that are tastefully adorned with flowers and shrubbery. The streets and sidewalks are clean, and free from dust and mud at all times, being covered with ferruginous sand and gravel that cements into a natural pavement.

There is an appearance of thrift on every hand, and the hospitable citizens are untiring in their attention to visitors. To enumerate all to whom I am under obligations for courtesies and aid in making my examinations while at Corydon, would occupy too much space in this brief notice, but I can not, even here, omit to speak of the assistance received from Hon. Thomas C. Slaughter, Benjamin P. Douglass, Dr. H. S. Wolf, Wm. T. Scott, Lieut. George Wilson, Henry Jordan, D. Jordan, Samuel J. Wright, Thomas McGrain, Samuel B. Lockett, Dr. J. C. Clark, Dr. Wm. Reader, and Rev. Thomas G. Beharrel.

A well has been bored for salt brine at Corydon, to the depth of one thousand and fifty feet, where the work is temporarily stopped. Moderately good brine was found at the depth of fifty-seven feet. At five hundred and twenty feet, the brine indicated thirty degrees of strength by the salometer. The greatest strength found was thirty-eight degrees at a depth of about seven hundred feet. Brine from a depth of six hundred and thirty feet was sent to the laboratory, some time last spring, for examination; it had a specific gravity of 1.064, and gave twelve and a half ounces of pure salt to the gallon of brine. One of the principal objects in carrying the well below the strongest brine, was to procure a flow of carburetted hydrogen gas that could be made

available as fuel for evaporating the water. Though small quantities of gas that would ignite and burn for a moment were found at different depths, no large quantity has yet been reached. The bore is now in a hard, gray limestone, and, in all probability, just above the Cincinnati group. If a sufficient quantity of gas is not found after reaching the shales of this group, it will not, in my opinion, justify to carry the bore deeper.

I visited an exposure of lithographic stone on Mr. Bringman's land, four miles southwest of Corydon. Lithographic stone is common in the subcarboniferous formation along the entire outcrop in Indiana, but as a general thing, the rock contains too many flaws and specks of calc-spar to furnish stone of good size. Here, however, judging from all I could see at an unworked exposure, perfect slabs of large dimensions may be had; and I had the promise of one upon which I expected to have had drawn a number of illustrations for this report.*

In the same hill and lying above the lithographic bed are several layers of compact, fine-grained limestone that take a good polish; the colors are handsome, being mottled with black, reddish gray and dark brown, on a light gray base. These marbles may be used for ornamental work, such as table tops, mantles, etc.

One and a half miles east of Corydon, on the New Albany gravel road, there is a sulphur well, owned by Mr. Amos Zenor. It emits a strong odor of sulphuretted hydrogen, and is highly extolled for its curative properties by those who have tried it. According to an analysis made by Dr. Thomas E. Jenkins of Louisville, it contains 450.88 grains of salts in a wine gallon, consisting of bicarbonate of soda, bicarbonate of magnesia, sulphate of soda, sulphate of magnesia, sulphate of lime, chloride of sodium, chloride of

*Since the above was written a letter has been received from Hon. Thomas C. Slaughter, in which he states that a slab two feet wide, three feet long and six inches thick, had been taken out, too late, however, to be made available.

magnesium, chloride of calcium, silica, gases in solution, carbonic acid and sulphuretted hydrogen.

The well is thirty-eight and a half feet deep, and gives an abundant supply of water at all times.

Between the sulphur well and town there is a very large spring of cool, fresh water, known as the "Blue spring," owned by Mr. Heath. This spring has generally been thought, from old tradition to that effect, to be at least five hundred feet deep. Such a phenomenon was quite unlooked for, and I was anxious to test the matter. After obtaining a great quantity of string, seventeen feet proved ample to reach the bottom. It is deep enough and large enough to supply the wants of a moderate sized city. Eight miles a little north of west from Corydon is Wilson's spring. This spring gives rise to a considerable stream, which is used for milling purposes, and drives a large grist and sawmill. The stone arch covering the water-way under the grist mill was built, it is said, by General Harrison, who once owned the property. The basin, where the water breaks up, is about one hundred and twenty feet wide, and flows with a rapid current through a channel about forty feet wide. As nearly as we could ascertain, by sounding from the shore with a cord attached to the end of a pole, we made the depth to be about fifty-five feet. The stream formed by this spring is one of the principal tributaries to Blue river. It was quite muddy from the effects of the heavy rains which had fallen the day before our visit. Below its confluence with Blue river the latter stream was quite muddy, while above it the water was clear.

The muddy condition of the water of the spring is accounted for upon the theory that it receives the drainage water from a large field six miles north, where the water, which floods the ground at times, runs into a hole and disappears beneath the surface; straw has been carried, it is said, by this means from the field to the spring. Be this as it may it is evident that the Wilson spring receives a large amount of surface drainage water from subterranean sources, as that which is derived from the grassy banks surrounding

the basin could not have muddied the spring to the extent we saw it. The entire country covered by the subcarboniferous limestone formation is more or less cavernous and filled with subterranean streams. From quite a number of wells in Corydon eyeless fish and crawfish have been brought up in the buckets when drawing water.

Pitman's cave is about one mile north of Wilson's spring. Though small, compared with Wyandotte, this cave is said to contain a number of chambers filled with beautiful stalactites and stalagmites and crystalizations of gypsum. I was not aware of this fact until after leaving the neighborhood, and had to postpone a visit to it until another time. Rhodes' cave, five miles southwest of Corydon, contains so much water that it has never been explored. It is reported to contain a great many eyeless fish, and I hope before long to find time to visit it for the purpose of collecting its subterranean fauna. Eyeless fish appear to be quite numerous in all subterraneous waters, and I take pleasure in acknowledging the receipt of three fine living specimens of these fish from Mr. Moses N. Elrod and George R. Bannring, who caught them last September at the Gulf of Lost River, in Orange county. They were placed in the aquarium at the Geological rooms, and at this writing appear to be doing well.

The citizens of Corydon kindly sent us in a coach to Wyandotte Cave, ten miles west, in the edge of Crawford county, and close to Blue river, which forms the eastern boundary of the county. Besides Mr. Samuel S. L. Smith, who has been with me since leaving New Albany, I was accompanied by Rev. Thomas G. Beharrel and Lieutenant Wilson, of Corydon. The road is a good one, and after crossing Blue river, follows along the side of the limestone bluff which skirts the stream, and affords, by a little excavation here and there, room for a road between it and the river.

We reached the cave at noon, and were gladly welcomed by the lessee of the cave and hotel, Mr. Conrad, his kind lady and daughter. After partaking of a good and substantial dinner, we prepared to visit the cave under the

guidance of our host. By measurement, with the aneroid barometer, the mouth of the cave is found to be about one hundred and fifty feet above the bed of Blue river, and we have from the top of the ridge to the river the following section :

Covered slope,	-	-	-	-	20 ft.
Buff sandstone, with stems of fossil plants,					80 ft.
Archimedes limestone,	-	-	-	-	5 ft.
Shale and brown limestone,	-	-	-	-	35 ft.
Gray limestone,	-	-	-	-	20 ft.
Limestone, fine-grained, lithographic and oolitic,	-	-	-	-	50 ft.
Gray, cherty, encrinital limestone,	-	-	-	-	230 ft.
Bed of Blue river,	-	-	-	-	0 ft.

The geological position of the Wyandotte Cave is precisely similar to that of the Mammoth Cave in Kentucky. It traverses the cherty beds of the sub-carboniferous formation which contain sink holes, large basin-shaped pits, and subterranean caverns in numerous places over its entire area. The Wyandotte Cave lies above the valleys, and in its course conforms to the general direction of the ridges *i. e.*, northeast and southwest. It is said to be twenty-two miles in extent, if all the branches which have been explored are included, but the various routes taken by visitors are estimated at a total of nineteen miles. The cave is dry, and contains a few narrow passages, such as "Fat Man's Misery," "Augur Hole," "Screw Hole," and "Creeping Avenue," but for the most part the galleries are broad and high and frequently expand into great rooms. The crystalline ornamentations are particularly fine, and far excel in number and beauty those seen in the Mammoth Cave. Two of the rooms, the "Senate Chamber" and "Mammoth Hall," are of immense size and impressively grand. The former contains the "Pillar of the Constitution," formed by a stalacto-stalagmitic deposit about twenty-five feet in diameter and thirty feet high, reaching from the top of a great stalagmite hill to the ceiling above. The surface is fluted

and divided by three bands, which give it the appearance of being jointed like a cane. Around the sides of the hill are numbers of stalagmites, of various sizes and heights, that with their shining tops look like clusters of cypress knees. Stalactites adorn the ceiling, and one very large one is called the "Bell," from the ringing sound which it emits when struck. On the right of the "Pillar of the Constitution" stands the "Chair of State," formed by a peculiar stalactostalagmitic arrangement. Behind and in front of the chair is a gallery richly adorned with these calcite ornaments, and when this immense room, capable of seating several thousand persons, is lighted up, it is impossible to conceive of a grander or more imposing spectacle. The other contains "Monument Mountain," said to be one hundred and seventy-five feet high, on the top of which stands three great stalagmites; one, which is very white and has the appearance of being draped, is called "Lot's wife;" "Wallace's Grand Dome" is seventy feet above the top of the mountain or two hundred and forty-five feet above the main floor of the cave. The width of the hall is three hundred feet. In speaking of these rooms, Professor Cope, in his paper on the fauna of the Wyandotte Cave, published in the July number of the *American Naturalist*, says, "There is no room in the Mammoth Cave equal to these two."

I can not, at this time, undertake to describe all the points of interest to be met with in nineteen miles of travel through this charming cave, but will briefly allude to the "White Cloud," room with its wave like walls and ceiling coated with glistening crystals, like a frosting of snow; the "Island of Confusion," and "Purgatory," where the rocks have the same rich coating; "Pillard Palace," with its innumerable stalactites, arranged in clusters, twisted and turned in all directions, like Pharoah's serpents; "Beauties Bower," where the walls are covered with gypsum rosettes as white as snow; the "Snow Banks," formed by alabaster in fine powder; the "Gallery," where the floor glistens with acicular crystals of gypsum, of which I obtained some samples not larger than a darning-needle, arranged in bundles

six inches long, which were as clear as water ; and the rooms where the stones are covered with fine hair like crystals of epsom salts, from one to two inches long.

There is very little water in this cave ; the sulphur spring is a small basin of water, contained in a mere shell of calcite, apparently formed by the water itself. Crawfish spring is a small body of water in a remote corner of the cave ; it occasionally furnishes a blind crawfish, and I obtained from it a number of small eyeless crustaceans.

Sibert's, or Little Wyandotte Cave, close to the hotel, is entered by descending about twenty feet through a small hole, on an Indian ladder. This is a small cave, probably not over two hundred yards in extent, and is not excelled, if equalled, by the Wyandotte, in the beauty and charming arrangement of its stalactites and stalagmites. In one instance the two are united and form a semi-transparent pillar which is ten feet in length and three inches in diameter, and extends from the floor to the ceiling. Visitors should not fail to see this cave also.

Half a mile north of the Wyandotte is the " Saltpetre Cave," where in early times saltpetre was made, and one of the lixiviating troughs is still to be seen. It has but one room, which is of gigantic size, and reaches upward into an immense " step-like " dome. This cave is also worth a visit.

I had the good fortune to secure the services of the eminent naturalist, Professor Edward D. Cope of Philadelphia, when he was in attendance at the Indianapolis meeting of the American Association for the Advancement of Science, to visit the Wyandotte cave and make a report on its fauna.

This interesting and valuable report will be found immediately following these notes.

It will be seen that Professor Cope collected sixteen species of cave animals ; but I was not so fortunate ; with the assistance of Mr. Smith, Mr. Conrad, and Mr. Sibert, only seven species were taken.

Centipedes, and the small crustacean that furnishes food for the blind fish, are abundant in the cave, and numbers

of them were collected. A blind fish, three blind crawfish, a small brown eyeless beetle and an out-door fish, "Miller's Thumb," were also collected in a small cave that is reached by going down a well at the foot of a ridge traversed by the Wyandotte cave.

The well is about twenty feet deep, and the bottom of the cave, to which it leads, is about on a level with the bed of Blue river.

In times of freshets, water fills the cave and flows out of the well. At the time of my visit the water was low, and only a very narrow and shallow stream was flowing through it, and we were compelled to crawl on our hands and knees over the slimy rocks, and occasionally in the water, in order to reach the small pool where we captured the eyeless fish and crawfish. Only one fish was seen, but the crawfish were frequently seen darting about in the clear water and crawling along the bottom. The latter soon became aware of our presence and effectually hid themselves beneath the rocks. The "Miller's Thumb" was caught on a ripple where the water was scarcely deep enough for him to swim. It is possible that this fish reached the cave through some channel which connects it with the river, or it may have been thrown into the well by some fisherman.

With the exception of its animals, there is nothing of special interest in this cave.

It may be well to state for the benefit of persons desiring to visit the Wyandotte cave, that it is thirty miles distant from New Albany, from which place there is a daily coach to Corydon, twenty miles, where hacks are to be had at all times for the remaining ten miles of the route, so that you may reach the cave before night. From Louisville there are packets which leave every evening at 5 o'clock and reach Leavenworth at about 11 o'clock P. M. the same day. Leavenworth is four miles from the cave, and you will find here good accommodations at the Ouerbacker Hotel, kept by Mrs. Humphries. Mr. Ouerbacker, her son, owns the wharf boat, and strangers will have no difficulty in finding their way to the hotel. Carriages are always

ready to take you out to the cave, which you will reach after an hour's ride over a romantic road.

Mr. H. W. Conrad, the lessee of the property, has established a large and commodious hotel at the cave. He is an accommodating gentleman, and you may be sure of kind treatment and comfortable quarters. Mr. Willis Sibert, the guide, has been raised on the property, and is well acquainted with every nook and corner of the cave, and under his guidance you can not fail to enjoy a visit to it. Indeed, no tourist should fail to visit the Wyandotte cave, where the grottoes filled with crystals rival in beauty the ideal grottoes of the genii, and the great domed rooms, with high hills surmounted by huge stalagmites, stand unrivaled among the subterranean wonders of the world.

Ladies who design visiting the cave should provide themselves with a Bloomer costume, made of flannel or some moderately warm goods. With such a dress they may, without inconvenience, go to every part that is explored. The temperature varies in the different parts of the cave, and ranges from 53° to 57° Fahrenheit. The air is pure and exhilarating, and very little fatigue is felt from long walks.

The Louisville and Henderson packet steamboats leave Leavenworth every evening, between 6 and 8 o'clock for Louisville, where they arrive next morning by daylight. Visitors going down the river may leave by these boats at 11 o'clock and reach Evansville by noon of the next day.

At Leavenworth, in this county, a bore has been started for salt brine, and is now 207 feet deep. Here it has been temporarily stopped by gravel falling in from a crevice which was struck 87 feet below the surface. After tubing below this crevice it is thought the difficulty encountered from gravel wedging in the drill may be removed, and the company design pushing the bore on down. In my opinion they will reach good brine at about 600 or 700 feet.

Eight miles from Leavenworth, on the west fork of Little Blue river there is a remarkable sulphur well. It was bored in 1864 for oil. At the depth of 275 feet in the subcarbon-

iferous limestone, a stream of "white" sulphur water was reached, which rushed up the well with tremendous force, carrying with it the tools, and put a stop to further boring. An ineffectual attempt has been made to test the height to which the well would throw water. A wooden tube, 45 feet long, was placed in the mouth of the bore, and the water flowed over the top, but the hydrostatic pressure was so great that it burst the bottom of the tube, and water was forced through the earth for many feet around. It is the common opinion that the water will rise, if properly confined, at least 70 feet.

The surface of the ground, and every object over which the water flows, is coated with a white deposit of sulphur. It is cool and clear, and has a strong odor of sulphuretted hydrogen gas, and its medicinal properties are highly extolled by all who have tested its virtues. Until recently there were no accommodations for invalids or other visitors, but now the well has fallen into the hands of Mr. R. A. Curry, who is making ample arrangements to render comfortable all who may desire to visit this great well, spouting at least 15,000 barrels of water per day, and test its hygienic powers. We found quite a number of visitors at the well, and among them Captain Holcroft and his family, Miss Roberts, of Kentucky, and Dr. Wood, of Cannelton, Indiana.

Mr. Robert H. Sands, of Leavenworth, accompanied me to the well, and laid me under further obligations by a present of some beautiful fossils from the carboniferous rocks of Kentucky.

In the northern part of Indiana there are a number of localities where fresh-water chalk (soft carbonate of lime) is found.

The deposits lie along the shores of the little island lakes which are so numerous in that part of the State. Some time last year, Hon. Stephen Davidson, member of the Indiana State Board of Agriculture, from Rochester, Fulton county, brought me a box of this chalk which he obtained near that place. It was analyzed and found to contain in 100 parts :

Moisture, dried @ 212° F.,	-	-	-	5.00
Organic matter,	-	-	-	4.50
Carbonate of lime,	-	-	-	81.10
Carbonate of magnesia,	-	-	-	1.51
Carbonate of alkalies,	-	-	-	6.18
Phosphate of lime,	-	-	-	.11
Alumina and oxide of iron	-	-	-	1.60
				100.00

While engaged in writing this report, other samples of fresh-water chalk have been received from DeKalb county. One sample, from F. W. McConnell, M. D., of Angola, was taken from a deposit on the shore of Silver lake, that is said to be 16 feet thick, and is nearly pure carbonate of lime. Another specimen was brought to the laboratory by Hon. E. B. Glasgow, of the same place, which was sent by Mr. O. Carpenter who struck it in digging a well, about half a mile back from the present shore of the lake.

The fact of finding this chalk at such a distance inland indicates that the bed has a considerable area, and that the shore line of the lake has been changed by a diminution in the volume of its water.

This chalk will make a good caustic lime, but on account of its purity, will require a much larger proportion of sand mixed with it in making mortar than lime that does not set so rapidly. It will also make an excellent fertilizer and an admirable mineral to mix with peat-muck for improving poor soils.

R E P O R T

ON THE

WYANDOTTE CAVE AND ITS FAUNA.

BY PROF. E. D. COPE.

The Wyandotte Cave traverses the St. Louis limestone of the carboniferous formation in Crawford County in southwestern Indiana. I do not know whether its length has ever been accurately determined, but the proprietors say that they have explored its galleries for twenty-two miles, and it is probable that its extent is equal to that of the Mammoth Cave in Kentucky. Numerous galleries which diverge from its known courses in all directions have been left unexplored.

The readers of the NATURALIST* have freshly in their memories the interesting papers of Messrs. Packard and Putnam on the fauna of the Mammoth Cave and related species. The writer accompanied the excursion so pleasantly described in the NATURALIST, and obtained most of the species there enumerated, as well as two or three additional ones which will be mentioned at the close of this article. On returning to Indianapolis at the request of Prof.

* American Naturalist, published at Salem, Mass., July number, 1872.

E. T. Cox, State Geologist of Indiana, I made an examination of the Wyandotte Cave, so far as two days' exploration could be called such. Having prepared by report, I present a portion of it, by permission of Prof. Cox, to the NATURALIST.

The Wyandotte Cave is as well worthy of popular favor as the Mammoth. It lacks the large bodies of water which diversify the scene in the latter, but is fully equal to it in the beauty of its stalactites and other ornaments of calcite and gypsum. The stalactites and stalagmites are more numerous than in the Mammoth, and the former frequently have a worm or macaroni-like form, which is very peculiar. They twist and wind in masses like the locks of Medusa, and often extend in slender runners to a remarkable length. The gypsum rosettes occur in the remote regions of the cave, and are very beautiful. There are also masses of amorphous gypsum of much purity. The floor in many places is covered with curved branches, and what is more beautiful, of perfectly transparent acicular crystals, sometimes mingled with imperfect twin-crystals. The loose crystals in one place are in such quantity as to give the name of "Snow Banks" to it. In other places it takes the form of japanning on the roof and wall rock.

In one respect the cave is superior to the Mammoth—in its vast rooms, with step-like domes, and often huge stalagmites on central hills. In these localities the rock has been originally more fractured or fragile than elsewhere, and has given away at times of disturbance, piling masses on the floor. The destruction having reached the thin-bedded strata above, the breaking down has proceeded with greater rapidity, each bed breaking away over a narrower area than that below it. When the heavily-bedded rock has been again reached, the breakage has ceased, and the stratum remains as a heavy coping stone to the hollow dome. Of course the process piles a hill beneath, and the access of water being rendered more easy by the approach to the surface, great stalactites and stalagmites are the result. In one place this product forms a mass extending from floor to ceiling, a

distance of thirty or forty feet, with a diameter of twenty-five feet, and a beautifully fluted circumference. The walls of the room are encrusted with cataract-like masses, and stalagmites are numerous. The largest room is stated to be 245 feet high and 350 feet long, and to contain a hill of 175 feet in height. On the summit are three large stalagmites, one of them pure white. When this scene is lit up, it is peculiarly grand to the view of the observer at the foot of the long hill, while it is not less beautiful to those on the summit. There is no room in the Mammoth Cave equal to these two.

I must not omit to mention the kind attention to the wants of his guests constantly displayed by Mr. Conrad, the present proprietor of the hotel, and the equally useful guidance of Mr. Rothrock, the owner of the cave. Visitors will also find on their way thither an American Auerbach's hotel at Leavenworth, near the steamboat landing. This excellent house is not haunted, like its European predecessor at Leipzig, by either a Mephistophiles or a Faust, but by a landlord (Mr. Humphreys), whose charges are low, and whose wife knows how, in lodgings and table, to satisfy reasonably fastidious persons.

An examination into the life of the cave shows it to have much resemblance to that of the Mammoth. The following is a list of sixteen species of animals which I obtained, and by its side is placed a corresponding list of the species obtained by Mr. Cooke and others at the Mammoth Cave. These number seventeen species. As the Mammoth has been more frequently explored, while two days only were devoted to the Wyandotte, the large number of species obtained in the latter, suggests that it is the richer in life. This, I suspect, will prove to be the case, as it is situated in a fertile region. Some of the animals were also procured from caves immediately adjoining, which are no doubt connected with the principal one.

Of the out-door fauna which find shelter in the cave, bats are of course most numerous. They are probably followed into their retreat by the eagle and large owls. The

floors of some of the chambers were covered to a considerable depth by the castings of these birds, which consisted of bats' fur and bones. It would be worth while to determine whether any of the owls winter there.

I believe that wild animals betake themselves to caves to die, and that this habit accounts in large part for the great collections of skeletons found in the cave deposits of the world. After much experience in wood craft, I may say that I never found the bones of a wild animal which had not died by the hand of man, lying exposed in the forest. I once thought I had found the place where a turkey vulture (*Cathartes aura*) had closed its career, on the edge of a wood, and it seemed that no accident could have killed it, the bones were so entire as I gathered them up one by one. At last I raised the slender radius; it was broken, and the only injured bone. I tilted each half of the shaft, and from one rolled a single shot! The hand of man had been there. One occasionally finds a mole (*Scalops* or *Condylura*) overcome by the sun on some naked spot, on his midday exploration, but if we seek for animals generally, we must go to the caves. In Virginia I found remains of very many species in a recent state; in a cave adjoining the Wyandotte I found the skeleton of the gray fox (*Vulpes Virginianus*.) In a cavern in Lancaster county, Pennsylvania, in an agricultural region, I noticed bones of five or six *Cistudines*, as many rabbits, and a few other wild species, with dog, horse, cattle, sheep, etc., some of which had fallen in.

LIST OF LIVING SPECIES IN THE TWO CAVES.

WYANDOTTE.

MAMMOTH.

Vertebrata.

Amblyopsis spelæus DeKay.

Amblyopsis spelæus DeKay.

Typhlichthys subterraneus Girard.

Arachnida.

Erebomaster flavescens Cope. j *Acanthocheir aramata* Tellk.

Phrixis longipes Cope.

Anthrobia.

Anthrobia monmouthia Tellk.

Crustacea.

Orconectes inermis Cope.	Orconectes pellucidus Tellk.
Cæcidotea microcephala Cope.	Cæcidotea stygia Pack.
Cauloxenus stygius Cope.	Stygobromus vitreus Cope.

Insecta.

Anophthalmus tenuis Horn.	Anophthalmus Menetriesii Motsch.
Anophthalmus eremita Horn.	Anophthalmus Tellkampfi Erichs.
Quedius spelæus Horn.	Adelops hirtus Tellk.
Lesteva sp. nov. Horn.	
Raphidophora.	Raphidophora subterranea Scudd.
Phora.	Phora.
Anthomyia.	Anthomyia.
Machilis.	Machilis.
Campodea sp.	Campodea Cookei Pack.
Tipulid.	

Myriopoda.

Spirostrephon cavernarum Cope. Scoterpes Copei (Pack.) Cope.

The blind fish of the Wyandotte Cave is the same as that of the Mammoth, the *Amblyopsis spelæus* DeKay. It must have considerable subterranean distribution, as it has undoubtedly been drawn up from four wells in the neighborhood of the cave. Indeed, it was from one of these, which derives its water from the cave, that we procured our specimens, and I am much indebted to my friend N. Bart. Walker, of Boston, for his aid in enabling me to obtain them. We descended a well to the water, some twenty feet below the surface, and found it to communicate by a side opening with a long low channel, through which flowed a lively stream of very cool water. Wading up the current in a stooping posture, we soon reached a shallow expansion or pool. Here a blind crawfish was detected crawling round the margin, and was promptly consigned to the alcohol bottle. A little further beyond, deeper water was reached, and an erect position became possible. We drew the seine in a narrow channel, and after an exploration under the bordering rocks secured two fishes. A second haul secured another. Another was seen, but we failed to catch it, and on emerging from the cave I had a fifth securely in my hand, as I thought, but found my fingers too numb to prevent its freeing itself by its active struggles.

If these Amblyopses be not alarmed, they come to the surface to feed, and swim in full sight like white aquatic ghosts. They are then easily taken by the hand or net, if perfect silence is preserved, for they are unconscious of the presence of an enemy except through the medium of hearing. This sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., on the bottom. They must take much of their food near the surface, as the life of the depths is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is directed partly upwards, and the head is very flat above, thus allowing the mouth to be at the surface. It thus takes food with less difficulty than other surface feeders, as the perch, etc., where the mouth is terminal or even inferior; for these require a definite effort to elevate the mouth to the object floating on the surface. This could rarely be done with accuracy by a fish with defective or atrophied visual organs.* It is therefore probable that fishes of the type of the *Cyprinodontidæ*, the nearest allies of the *Hypsæidæ* and such *Hypsæidæ* as the eyed *Chologaster*, would possess in the position of the mouth a slight advantage in the struggle for existence.

The blind crawfish above mentioned is specifically distinct from that of the Mammoth Cave, though nearly related to it. Its spines are everywhere less developed, and the abdominal margins and cheles have different forms. I call it *Orconectes inermis*, separating it generically from *Cambarus*, or the true crawfishes, on account of the absence of visual organs. The genus *Orconectes*, then, is established to include the blind crawfishes of the Mammoth and Wyandotte Caves. Dr. Hagen, in his monograph of the American Astacidæ, suspects that some will be disposed to separate the *Cambarus pellucidus* as the type of special genus, but thinks such a course would be the result of erroneous rea-

* Mr. Putnam's objection to my reasoning from the structure of the Amblyopsis' mouth was based on a misconception of my meaning. The above explains the point more fully.

soning. Dr. Hagen's view may be the result of the objection which formerly prevailed against distinguishing either species or genera whose characters might be suspected of having been derived from others by modification, or assumed in descent.

The prevailing views in favor of evolution will remove this objection; and for myself I have attempted to show* that it is precisely the structural characters which are most obviously, and therefore most lately, assumed on which we have been in the habit of depending for discrimination of genera. The present is a case in point. So far also as the practice of naturalists goes, this course is admissible, for the presence or absence as well as the arrangement of the eyes have long been regarded as generic indications among the Myriopoda and Arachnida. Without such recognition of a truly structural modification our system becomes unintelligible.

Dr. Packard described in his article already quoted, an interesting genus of Isopoda allied to the marine form *Idotea*, which Mr. Cooke discovered in a pool in the Mammoth Cave. He called it *Cæci-*

Fig. 109.

dotea. I obtained a second species in a cave adjoining the Wyandotte, which differs in



Cæcidotea microcephala Cope, magnified 6.5 times.

several important respects. The head is smaller and more acuminate, and the bases of the antennæ are more closely placed than in *C. stygia* Pack. I call it *Cæcidotea microcephala*. Both species are blind. The new species is pure white. It was quite active, and the females carried a pair of egg pouches full of eggs. The situation in which we found it was peculiar. It was only seen in and near an empty log trough used to collect water from a spring dripping from the roof of one of the chambers.

The Lernæan *Cauloxenus stygius* Cope, is a remarkable

*Origin of Genera p. 41

Fig. 110.



Cacidotea microcephala Cope. The mandible and palpi of right side more enlarged. The outer palpus lies above the lateral plate, and its origin was not seen.

creature. It is a parasite on the blind fish, precisely as numerous species near of kin, attach themselves to various species of marine fishes. The Wyandotte species is not so very unlike some of these. It is attached by a pair of altered fore-limbs, which are plunged into the skin of the host and held securely in that position by the barbed or recurved claws. The position selected by the blind fish *Lernæan*, was the inner edge of the upper lip, where she hung in a position provocative of attempts at mastication on the part of the fish and reminding one of the picture of the man on the ass, back holding a fork of fodder before the animal's nose, in illustration of the motto that "persuasion is better than force." The little creature had an egg pouch suspended on each side, and was no doubt often brought in contact with the air by her host.

This position would not appear to be a favorable one for long life, as the body of the *Cauloxenus* would be at once caught between the teeth of the fish, should its direction be reversed or thrown backwards. The powerful jaw-arms, however, maintained like a steel spring a direction at a strong angle with the axis of the body, which was thrown upwards

Fig. 111.



Cauloxenus stygius in position on the lip of *Amblyopsis opaculus*, enlarged.

over the upper lip, the apex of the cephalothorax being between the lips of the fish. This position being retained, it becomes a favorable one for the sustenance of the parasite, which is not a sucker or devourer of its host, but must feed on the substances which are caught by the blind fish, and crushed between its teeth. The fragments and juices expressed into the water must suffice for the small wants of this crustacean.

But if the supply of food be precarious, how much more so must be the opportunities for the increase of the family.

No parasitic male was observed in the neighborhood of the female, and it is probable that as in the other *Lernæopodidæ*, he is a free swimmer, and extremely small. The difficulty of finding his mate on an active host-fish must be augmented by the total darkness of his abode, and many must be isolated owing to the infrequent and irregular occurrence of the fish, to say nothing of the scarceness of its own species.

Fig. 113.



Caulozenus stygius. A antennal process and muzzle more enlarged.

The allied genera, *Achtheres* and *Lernæopoda*, present very distinct distributions, the former being fresh water and the latter marine. *Lernæopoda* is found in the most varied types of fishes and in several seas; *Achtheres* has been observed on

Fig. 112.



Caulozenus stygius. The animal viewed from below, with an infero-lateral view of the cephalothorax.

perch from Asia and Europe, and in a South American *Pimelodus*. It is to the latter that *Caulozenus* is most nearly allied, and from such a form we may perhaps trace its descent; modification being consequent on its wandering into subterranean streams. The character which distinguishes it from its allies, is one which especially adapts it for maintaining a firm hold on its host, *i. e.*, the fusion of its jaw-arms into a single stem.

Whether the present species shared with the *Amblyopsis* its history and changes, or whether it seized upon the fish as a host at some subsequent period, is a curious speculation. Its location at the mouth of the fish could scarcely be maintained on a species having sight, for if the host did not remove it, other individuals would be apt to.

I may here allude to another blind Crustacean which I took in the Mammoth Cave, and which has been already mentioned in the Annals and Magazine of Natural History as a Gammaroid. Mr. Cooke and myself descended a hole, and found a short distance along a gallery, a clear spring covering, perhaps, an area ten feet across. Here Mr. Cooke was so fortunate as to procure the *Cecidotea stygia*, while I took the species just mentioned, and which I name *Stygobromus vitreus*. The genus is new and represents in a

measure the *Niphargus* of Schiodte found in the caves of Southern Europe. It resembles, however, the true *Gammarus* more closely, by characters pointed out at the close of this article. This genus has several species in fresh waters, which are of small size, and swim actively, turning on one side or the other.

Of insects I took four species of beetles, all new to science. Two of them of the blind carnivorous genus *Anopthalmus*, and two *Staphylinidæ*, known by their very short wing-cases and long, flexible abdomen. Dr. George H. Horn has kindly determined them for me. One of them, the *Quedius spelæus* Horn, is a half inch in length, and has rather small eyes.* It was found not far from the mouth of the cave. Dr. Horn furnishes me with the following list of Coleoptera, from the two caves in question :

<i>Anopthalmus Tellkampfi</i> Erichs.	Mammoth Cave.
<i>Anopthalmus Menetriesi</i> Motsch,	
<i>angulatus</i> Lec.	Mammoth Cave.
<i>Anopthalmus eremita</i> Horn.	Wyandotte Cave.
<i>Anopthalmus tenuis</i> Horn.	Wyandotte Cave.
<i>Anopthalmus striatus</i> Motsch.	Mammoth Cave. Unknown to me.
<i>Anopthalmus ventricosus</i> Motsch.	Mammoth Cave. Unknown to me.
<i>Adelops hirta</i> Tellk.	Mammoth Cave.

These are the only true cave insects at present known in these fauna. Other species were collected within the mouths of the caves, but which can not be classed with the preceding, as cave insects proper.

<i>Catops</i> n. sp.?	Wyandotte Cave
<i>Quedius spelæus</i> Horn.	Wyandotte Cave.
<i>Lesteva</i> n. sp.	Wyandotte Cave.

And another Alæocharide Staphylinide, allied to *Tachyusa*, also from Wyandotte Cave. No names have as yet been given to any of these excepting the second. A monograph of *Catops* has already appeared containing many species from our fauna, and as the work is inaccessible at present, I have hesitated to do more than indicate the presence of the above species.

*See Proceed. Amer. Entom. Soc., 1871, p. 332.

Two other species of true cave insects are known in our fauna; *Anophthalmus pusio* Horn, (Virginia) Erhart's Cave, *Anophthalmus pubucens* Horn, (Illinois) Cave City Cave.

The cricket of the Wyandotte Cave is stouter than that of the Mammoth and thus more like the *Raphidophora lapidicola* of the forest. There were three species of flies, one or more species of *Poduridæ* and a *Campodea* not determined.

Centipedes are much more abundant in the Wyandotte than in the Mammoth Cave. They especially abounded on the high stalagmites which crown the hill beneath the Mammoth dome, which is three miles from the mouth of the cave. The species is quite distinct from that of the Mammoth Cave and is the one I described some years ago from caves in Virginia and Tennessee. I call it *Spirostrephon cavernarum*, agreeing with Dr. Packard that the genus* to which it was originally referred is of doubtful validity. The species is furnished with a small triangular patch of eyes, and is without hairs, but the antennæ are quite elongate. Its rings are quite handsomely keeled. The allied form found by Mr. Cooke in the Mammoth Cave has been described by Dr. Packard as *Spirostrephon Copei*. It is eyeless and is, on this account alone, worthy of being distinguished generically from *Spirostrephon*, though the absence of pores asserted by Dr. Packard, would also constitute another character. *Spirostrephon* possesses a series of lateral pores as I have pointed out in accordance with Wood's view.† This genus may be then named *Scoterpes*. I look for the discovery of *S. cavernarum* in the Mammoth Cave.

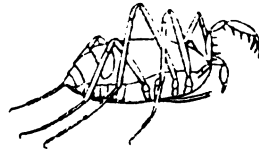
Two species of Arachnidans were observed, one a true spider, the other related to the "long-legs" of the woods. A species, similar to the former is found in the Mammoth Cave, and others in other caves, but in every instance where I have obtained them, they have been lost by the dissolution of their delicate tissues in the impure alcohol. The

**Pseudotremia*.

†Proceed. Amer. Entom. Soc., 1870.

other forms are more completely chitinized and are easily preserved. They are related to the genus *Gonyleptes* found under stones in various portions of the country. Dr. Wood describes a species from Texas, and I have taken them in Tennessee and Kansas. In the Wyandotte Cave I found a number of individuals of a new species at a place called the Screw Hole. This is a narrow passage between masses of rock, which rise from the end of a gallery to the floor of a large room called the Senate Chamber. Though living at a distance of four or five miles from the mouth of the cave, this species is furnished with eyes. Its limbs are not very long, but its palpi are largely developed, and armed with a double row of long spines pinnately arranged, like its relative of the Mammoth Cave, the *Acanthocheir*. This species is described at the end of the article as *Erebomaster flavescens* Cope. In its relationships it may be said to stand between *Acanthocheir* and *Gonyleptes*.

Fig. 114.



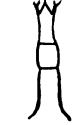
Erebomaster flavescens, magnified 7.6 times.*

Besides *Acanthocheir*, another blind Gonyleptid exists in the Mammoth Cave, which I found several miles from the mouth. It is blind like the former, but differs in having many more joints to the tarsi, approaching thus the true *Phalangia*, or long-legs. There are six joints and terminal claws, while *Acanthocheir* is said to have two and *Erebomaster* three joints. It is larger than *A. armata*, and has much longer legs. Its palpi are also longer and their spines terminate in long hairs. I have named it *Phrixis longipes*.

Dr. Packard and Mr. Putnam, have already discussed the

*Our engraver has not correctly represented the posterior lateral border of the large dorsal scutum. The mandible should also have been represented as terminating in a pair of nippers.—Eds.

Fig. 115.



Erpob-
master
flaves-
cent
Male or-
gan from
below.

question of the probability of the origin of these blind cave animals by descent from out-door species having eyes. I have already expressed myself in favor of such view, and deem that in order to prove it, we need only establish two or three propositions. First, that there are eyed genera corresponding closely in other general characters with the blind ones; second, that the condition of the visual organs is in some cave type variable; third, if the abortion of the visual organs can be shown to take place coincidentally with general growth to maturity, an important point is gained in explanation of the *modus operandi* of the process.

First, as to corresponding forms; the *Typhlichthys* of the Mammoth is identical* with *Chologaster*, except in its lack of eyes. *Orconectes* bears the same relation to *Cambarus*; *Stygobromus* bears nearly the same to *Gammarus*, and *Scotterpes* is *Spirostrephon* without eyes, and no pores.

Secondly, as to variability. I have already shown that in *Gronius nigrilabris*, the blind Silurid from the Conestoga in Pennsylvania, that while all of several specimens observed were blind, the degree of atrophy of the visual organs varies materially, not only in different fishes, but on different sides of the same fish. In some, the corium is imperforate, in others perforate on one side, in others on both sides, a rudimental cornea being thus present. In some, the ball of the eye is oval and in others collapsed. This fish is related specifically to the *Amiurus nebulosus* of the same waters, more nearly than the latter is to certain other Amiuri of the Susquehanna river basin to which the Conestoga belongs, as for instance the *A. lynx*; it may be supposed to have been enclosed in a subterranean lake for a shorter time than the blind fishes of the Western caves, not only on account of the

*Mr. Putnam shows that the known species of *Chologaster* differ from those of *Typhlichthys* in the lack of the papillary ridges, which is probably another generic character similar to the loss of eyes. The absence in *Chologaster* of minute palatine teeth, and the presence of an additional pair of pyloric cæca, which he mentions, will be apt to prove only specific.

less degree of loss of visual organs, but also in view of its very dark colors. A feature on which I partly relied in distinguishing the species, has perhaps a different meaning. The tentacles or beards were described as considerably shorter than those of allied species. On subsequently examining a number of individuals, I was struck with the irregularity of their lengths, and further inspection showed that the extremities were in each case enlarged, as though by a cicatrix. I have imagined that the abbreviation of the tentacles is then due to the attacks of carnivorous fishes which inhabit the subærial waters into which the *Gronias* strays, from whom its blindness renders it unable to protect itself.

Thirdly, it is asserted that the young *Orconectes* possess eyes and that perhaps those of the *Typhlichthys* do also. If these statements be accurate, we have here an example of what is known to occur elsewhere; for instance, in the whale-bone whales. In a foetal stage, these animals possess rudimentary teeth like other Cetacea, which are subsequently absorbed. This disappearance of the eyes is regarded with reason by Professor Wyman as evidence of the descent of the blind forms from those with visual organs. I would suggest that the process of reduction illustrates the law of "retardation," accompanied by another phenomenon. Where characters which appear latest in embryonic history are lost, we have simple retardation; that is, the animal in successive generations fails to grow up to the highest point, falling farther and farther back, thus presenting an increasingly slower growth in this special respect. Where, as in the presence of eyes, we have a character early assumed in embryonic life, the retardation presents a somewhat different phase. Each successive generation, it is true, fails to come up to the completeness of its predecessor at maturity, and thus exhibits "retardation," but this process of reduction of the rate of growth is followed by its termination in the part, long before growth has ceased in other organs. This is an exaggeration of retardation. Thus the eyes in the *Orconectes* probably once exhibited at maturity the incomplete characters now found in the young, for a long time a retarded

growth continuing to adult age before its termination was gradually withdrawn to earlier stages. Growth ceasing entirely, the phase of atrophy succeeded, the organ becomes stationary at an early period of general growth, being removed, and its contents transferred to the use of other parts by the activity of "growth force." Thus for the loss of late assumed organs we have "retardation," but for that of early assumed ones, "retardation and atrophy."

In comparing the list of animals from the Wyandotte with that of the Mammoth Cave, it will be observed that the representatives in the former, of two of the blind genera of the latter, are furnished with eyes. These are the *Erebomaster* and *Spirostrephon* which correspond with the *Acanthocheir* and *Scoterpes* respectively. In the outer part of a branch of the Wyandotte I took two eyed beetles the *Que dius spelæus* and a *Platynus*.

The out-door relatives of the blind forms are various. Those having congeners outside are the *Spirostrephon*, *Campodea*, *Machilis Phora*, *Raphidophora*. Those with near but few allies, the *Scoterpes*, *Amblyopsis* and the three *Gonyleptidæ*. Species of the latter are much more rare in this country than those of *Phalangidæ*, which are not known from the caves. The *Orconectes* is mostly fresh water in kindred, while Packard shows that those of the *Cæcidotea* are marine. Those of the *Cauloxenus* are partly marine, and those of the *Stygobromus* fresh water and marine.

The mutual relations of this cave life form an interesting subject. In the first place, two of the beetles, the crickets, the centipede, the small crustaceans (food of the blind fish) are more or less herbivorous. They furnish food for the spiders, crawfish, *Anophthalmus*, and the fish. The vegetable food supporting them is in the first place fungi, which in various small forms, grow in damp places in the cave, and they can always be found attached to excrementitious matter dropped by the bats, rats and other animals which extend their range to the outer air. Fungi also grow on the dead bodies of the animals which die in the caves, and are found abundantly on fragments of wood and boards brought in by human

agency. The rats also have brought into fissures and cavities communicating with the cave, seeds, nuts and other vegetable matters, from time immemorial, which have furnished food for insects. Thus rats and bats have, no doubt, had much to do with the continuance of land life in the cave, and the mammals of the post-pliocene or earlier period, which first wandered and dwelt in its shades were introducers of a permanent land life.

As to the small crustaceans, little food is necessary to support their small economy, but even that little might be thought to be wanting, as we observe the clearness and limpidity of the water in which they dwell. Nevertheless the fact that some cave waters communicate with outside streams is a sufficient indication of the presence of vegetable life and vegetable debris in variable quantities at different times. Minute fresh water algae no doubt occur there, the spores being brought in by external communication, while remains of larger forms, as *confervæ*, etc., would occur plentifully after floods. In the Wyandotte cave no such connection is known to exist. Access by water is against the current of small streams which discharge from it. On this basis rests an animal life which is limited in extent and must be subject to many vicissitudes. Yet a fuller examination will probably add to the number of species and of these, no doubt, a greater or less number of parasites on those already known. The discovery of the little *Lernæan* shows that this strange form of life has resisted all the vicissitudes to which its host has been subjected. That it has outlived all the physiological struggles which a change of light and temperature must have produced, and that it still preys on the food of its host as its ancestors did, there is no doubt. The blindness of the fish has favored it in the "struggle for existence," and enabled it to maintain a position nearer the commissariat, with less danger to itself than did its forefathers.

DESCRIPTIONS OF SPECIES FROM THE
WYANDOTTE CAVE.

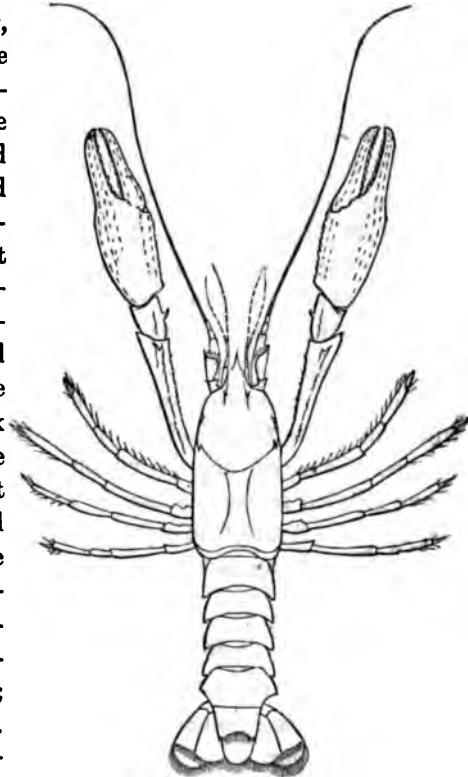
ORCONNECTES COPE.

Genus novum. Similar to *Cambarus*, but with the eyes rudimental with the cornea small and not faceted. The present genus embraces two species, the *O. inermis* of the Wyandotte and the *O. pellucidus* of the Mammoth Cave.

O. INERMIS Cope, sp. nov. This species is near the *O. pellucidus*, and differs as follows. Its proportions are generally less slender, and the spines less developed. The frontal process is

Fig. 116.

considerably shorter, the terminal spine not extending beyond the apex of the antennal lamellæ and very little beyond the point of bifurcation of the first antennæ. In *O. pellucidus* the spine extends much beyond these points. The lateral points mark the middle of the length and support very rudimental spines; they are elongate in *O. pellucidus*. The basal lateral ridges are marked and convergent; basal spines short. The antennal lamellæ are much enlarged



Orconectes inermis Cope, nat. size.

at the middle and contracted below, and are furnished with a fringe of long hairs. At the base of the second antenna

the margin of the thorax has a projecting convexity moderately developed. On the side of the thorax there is a small patch of weak prickles, and there are two on the anterior lateral suture of the abdomen. In *O. pellucidus* these spines are larger and much more numerous. The lateral outlines of the postabdominal segments are those of one extremity of an ellipse with a slight angulation at the extremity; in *O. pellucidus*, these are rectangular, with the hinder margin straight distally.

The cheles are slender, but less so than in *O. pellucidus*, the opposed processes are flat and not ridged along the middle as in that species, and the general surface is smooth or nearly so, without the tubercular roughness of *O. pellucidus*. The cheles of the second and third legs partake of the broader form of the first. The third femora of the third and fourth legs with short hooks. The spines of the basal segments of the first legs are much as in the old species. The shell of the specimen taken early in September was very soft on the abdominal segment, but well calcified elsewhere. Color white. Total length head and body, m.054 ($=2\frac{1}{2}$ in.). Length spine from thorax margin .0055. Length cheliform segment of first legs, .024; width do., .0075; length movable (last) segment of do., .0123.

The single specimen of this species has been compared with four of the *O. pellucidus* in the Museum of the Academy Natural Sciences, one of which is young; the characters above alluded to are constant. They are also exhibited by Dr. Hagen's figure,* except the slenderness of the cheles, which is less than in our specimens. This figure is copied by Dr. Packard.

CÆCIDOTEA PACKARD.

C. MICROCEPHALA Cope, sp. nov. Unknown crustacean with external egg-pouches, Cope. Ann. Magaz. Nat. Hist., 1871, November.

Abdominal segments confluent into a single one; thoracic

* Catalogue of the Museum Comparative Zoology. Monograph of the *Asacidae* of North America.

segments seven, well distinguished. Inner antennæ close together, situated between the larger outer ones both issuing from below the margin of the dorsal plate of the cephalic segment. The specimens are in bad condition, having lost their limbs, egg-pouches and the distal portions of their antennæ. The head is small, narrower and scarcely longer than the first thoracic segment. The segments are all smooth and without hairs or sculpture. The abdominal segment is quadrate-oval, truncate posteriorly, without projection or mucro, above regularly, but slightly convex. Egg-pouches well separated, oval in form, moderate in size. The limbs are given off from the free extremities of the segments. Branchial laminæ extending to the extremity of the abdominal segment, in contact throughout on the median line. Color pure white. Length with egg-pouches, but with only four basal joints of antennæ, 5-16th of an inch (m.0077.)

This species is near the *Cæcidotea stygia* of Dr. Packard (American Naturalist, 1871, pp. 751-2) and, as such, of much interest. It has a much smaller and more acuminate head than the *Cæcidotea stygia* Pack., though in general the species are not very different in other respects, and are of about the same size. In the *C. microcephala* the abdomen is truncate, in the longer known species, angulate.

This species may then be regarded as the representative of the *C. stygia* in the Wyandotte Cave.

CAULOXENUS COPE.

Fam. *Lernæopodidæ* Gerst. The adult female stout, sack-like, not articulated. Cephalothorax not elongate, large, separated from the abdomen by a strong constriction. Anchor or jaw-feet elongate, arm-like, closely united throughout their length, originating at or behind the middle of the cephalothorax. Cephalothorax undivided, abdomen rounded, sack-shaped, not segmented. Egg-pouches, short, wide.

This genus differs from its allies, *Achtheres* and *Lernæo-*

poda in the fusion of the jaw-limbs, between which a faint dividing depression only may be distinguished, when they are viewed from below. The form of the abdomen is much as in *Achtheres*, but segmentation is not distinguishable. The short, wide egg-sacks are as in other genera of this family; they are well separated and are filled with large, globular eggs.

The structure of the mouth organs is not readily determinable in my single specimen, owing to the intervention of the very stout jaw-feet. They are only visible in profile (see fig. 106.) A pair of perhaps first antennal segments projects from the head, is curved upwards and is without terminal bristle or hook; a short process at the base may represent a tactile appendage. The inferior antennæ are well marked and equally without appendage. There are some bodies between them, perhaps on the middle line, whose nature is not determinable. There is no trace of eyes. The chitinous stem of the common jaw-feet is rather long, and expands discoidally at the extremity.

C. STYGIUS Cope. *Proceed. Acad. Nat. Sci., Phila., 1871, p. 297.* Cephalothorax nearly as long as abdomen, oval, subcompressed; abdomen subround, subdepressed, separated by a rather long constriction. Egg-sacks rounded, shorter than abdomen, on very short pedicels. Jaw-limbs nearly as wide as the abdomen, and not quite so long, much constricted distally at the point of origin of the anchoring stem, which is nearly as long as the arm proper. No dermal appendages of any kind. Rostral region projecting above the arms, subconical. Color uniform whitish. Length (without anchor-claws) 0m.003.

EREBOMASTER COPE.

Ganus novum, familiæ *Gonyleptidarum*. Cephalothoracic shield extending over a considerable part of the abdomen, which has seven segments. Tarsus with three joints and a terminal claw. Palpi with five joints and a claw, the fourth and fifth with a series of strong spines on each side. Man-

dibles chelate. Cephalothorax with a median conical eminence, which has an ocellus on each side of its base. Posterior trochanters like the others.

This genus is related to the *Acanthocheir* of Lucas, which has been recently figured in the Naturalist. According to Wood that genus is eyeless. Dr. Packard's figure presents many peculiarities. Thus the abdomen is not represented as segmented, and there is no distinct cephalothoracic shield; the tarsi are represented as only two-jointed. From this and other facts, I suspect that *Acanthocheir* should be placed near *Erebomaster* among the *Gonyleptidæ*.

E. FLAVESCENS Cope, sp. nov. "Opilio-like Spider," Cope, Ann. Magaz. Nat. Hist., November, 1871. Body smooth, limbs very minutely hairy. Two spines at the extremity of the penultimate tibia. Three or four spines at the base of the third segment of the palpi, not longer than those of the third, which has four on the outer side. Spines of last joint longest. The longest limbs are about twice as long as the total length of the body. Maxillæ rather long. Color a light brownish yellow. Length of head and body m.0025.

In one specimen the male organ is protruded and extends to the mandibular cheles; it is not chitinized and appears to be twice segmented. It terminates in a short point with mucro, which is flanked on either side by a point with two divergent bristles.

ANOPHTHALMUS STURM.

A. TENUIS Horn. Pale, rufo-testaceous, shining. Head slightly darker in color, oval and arcuately biimpressed. Thorax broader than the head, slightly longer than broad, and sinuately narrowing to hind angles, which are exactly rectangular; median line distinctly impressed in its entire length; basal impression deep; base of thorax truncate. Elytra elongate oval, feebly convex, at base slightly flattened; two-thirds longer than broad; humeri obtusely rounded, surface with feeble traces of striæ and three dorsal setiger-

ous punctures on each elytron, in or nearest to the position of the third stria. Body beneath similar in color to the upper surface, legs somewhat paler. Length .18-.24 inch; 4.5-6mm.

Three specimens of this species were collected. This species is closely allied to *A. Menetriesi* Motsch. (*angulatus* LeC.) but differs by its more elongate and less robust form and less convex surface. The elytra are smoother and with very feeble traces of striae. The two species differ, especially in the form of the hinder thoracic angles and base of thorax. In *Menetriesi*, the angles are acute, slightly prominent externally and the base of the thorax slightly prolonged, while in the present species the angles are strictly rectangular and the base truncate. This species must be placed near the one just cited in my table of our species. (Trans. Ent. Soc., Phil., 1868, p. 126.)

The new species above described is the most slender in form of any in our cabinets.

A. EREMITA Horn. Pale, rufo-testaceous, feebly shining. Head oval, arcuately biimpressed, impressions moderately deep, intervening space feebly convex. Thorax wider at widest portion than long, sides moderately rounded in front, gradually narrowed to base, hind angles rectangular, base truncate and as wide as length of thorax; disc feebly convex, median line distinctly impressed, basal transverse impression moderate. Elytra oval, less shining than thorax and sparsely clothed with very short, erect pubescence; striae obsolete; three dorsal punctures on the line of the third stria. Length .20 inch, 5mm.

One specimen of this species was collected with preceding in Wyandotte Cave. The only species with which it might be confounded is that previously described by me under the name *A. pusio*, and although differing very notably on comparison in their general aspect, the points of difference are not easily made plain in a description. The present species is in all respects broader and less depressed, without being convex as in *Menetriesi*; the thorax is broader, less narrowed behind, and the sides more rounded. The elytra are

less shining and the pubescence more distinct, although in both species the pubescence can only be observed by holding the specimen between the eye and the light and then only with a good power. In the three species at the head of my analytical table, no signs whatever of pubescence can be observed. The elytral striæ are here obliterated, faint traces are discernable only at the base. The basal margin is not prolonged.

QUEDIUS LEACH.

Q. SPELÆUS Horn. Pale, rufo-testaceous, shining. Head broadly oval, smooth, shining, slightly impressed between the eyes in front; two punctures bearing short setæ in front of the eyes, another at the side of the vertex, two at the side of head behind, hind angle of head slightly pubescent. Eyes not large, nearly round and prominent. Antennæ moderately stout, one-half longer than the head, first joint nearly as long as the second and third together, the third one-half longer than the second; joints 4-10, gradually but feebly stouter, cylindrical and scarcely longer than wide, joint 11, longer than preceding and subacute at tip. Thorax slightly broader than the elytra, sides distinctly explanate, broader than long, emarginate in front, anterior angles subacute, sides and base broadly rounded, forming nearly a circle, less the emargination in front; surface smooth, shining and with punctures arranged as follows: a dorsal series of two punctures moderately distant from the anterior margin, a lateral oblique series of three or four punctures, one puncture being within the line of the lateral but not belonging to the dorsal series; a marginal row of moderately large punctures close to the lateral margin extending along the base, the punctures being more distant in the latter region. Prosternal process behind the coxæ corneous. Scutellum smooth, shining. Elytra slightly longer than the thorax, rather densely and moderately coarsely punctured and sparsely clothed with yellowish pubescence. Abdomen moderately elongate, longer than the head, thorax and elytra together, slightly narrowed to apex, moderately

punctured but less densely than the elytra, above and beneath sparsely clothed with brownish hairs. Body beneath and legs similar in color to the upper surface. Length .46-.55 inch 11.5-12.5mm. Abundantly distinct from all our species by the color and thoracic punctures. The sides of thorax are more explanate than any of our species except *Q. explanatus* LeC.

Two specimens were collected a short distance within the mouth of Wyandotte Cave.

DESCRIPTIONS OF SPECIES FROM THE MAMMOTH CAVE.

PHRIXIS COPE.

Genus novum *Gonyleptidarum*. Cephalothoracic shield covering dorsum of abdomen, which is posteriorly segmented. Eyes none. Tarsi multiarticulate, clawed. Palpi spiniferous, maxillæ chelate.

This genus is near *Erebomaster*, differing in the multiarticulate tarsi, and absence of eyes. It is nearer to *Acanthocheir*, being like it, eyeless, but the latter, according to Dr Packard's figure (in AMERICAN NATURALIST, l. c.) has tarsi as in the first named genus, one or two jointed. In *Phrixis* they are much as in *Phalangium*, which the species also resembles in its long limbs.

PHRIXIS LONGIPES Cope, sp. nov. Legs eight times as long as the body, tarsus of the shorter with five, those of longer with six joints, those of the longest not counted. The first and second segments are very long; tibiæ shorter than femora; coxæ subglobular. Legs with scattered, rather short hairs. Last tarsal joint with one claw and an opposing bristle, in two limbs as long as femora, exceeding total of body, with two claws. Palpi five jointed, the third, fourth and fifth with large spines on each side, the second, or vertical, with four near the base directed forwards and two near the upper end directed inwards. Mandibles pubescent. Five narrow, and one terminal, segments of the abdomen,

the penultimate wider than the others. Body pubescent. Color very pale, with a straw-colored shade. Length of body 1.17 lines, or m.00225; longest leg m.02.

This species, though small, considerably exceeds the *Acanthoscheir armatus* in dimensions.

STYGOBROMUS COPE.

Gen. nov. *Gammaridarum*. Near *Gammarus*. The first antennæ with flagellum, and much shorter than the second. Two pairs of limbs chelate by the inflexion of the last claw-like segment; other limbs clawed. Terminal abdominal segment very short, spiniferous; the penultimate segment with a stout limb with two equal styles, the antepenultimate short, two-jointed and undivided. Eyes none.

This genus is nearer to the true *Gammarus* than the allied genus described from the Austrian Caves, the *Niphargus* of Schiodte.* In the latter the first antennæ are the larger, and the body terminates in a very long style; the last abdominal limb is undivided like that which precedes it. In *Stygobromus* the penultimate limb is like that represented by Schiodte for *Niphargus*, though I am not certain whether it is homologically identical. The last limb is about equally divided, but the simple basis is long and stout.

It is just possible that the antepenultimate limb represents the basis and one style only, for in that of one side a slight process appears at the extremity of the basal segment, though it is not visible on that of the other. The terminal limbs are recurved and appressed to the last abdominal segment, forming a fulcrum or prop. The animals of this genus are aquatic, and swim much as the common *Gammari*. The absence of eyes is another example of the adaptation to darkness.

STYGOBROMUS VITREUS Cope. "Gammaroid Crustacean" Cope, Ann. Mag. Nat. Hist., Nov., 1871. Two last pairs of limbs appressed to last abdominal bristles and of nearly equal length, forming a brush. Last segment of abdomen

*Proc. Entom. Soc., London, 1851, p. 150.

with two terminal bristles. Last segment of the limbs from the third to the seventh, with a long, straight claw directed forwards. Fringed limbs behind this point very small. Outer or second antennæ half as long as the first, which embrace eleven segments, and are about as long as the last five abdominal segments. Total length of head and body 2.1 lines or .0045m.

There are few conspicuous hairs, the most so are those which stand at the extremity of the last joint of the limbs, rising from the base of the claw. Color translucent.

ANALYSES OF COALS—PERRY COUNTY.

County.	NAME OF MINE OR OWNER.	Specific gravity.	Weight of one cubic foot.	Ashes.	Coke.	Gas.	Water.	Total Volatile Matter.	Color of Ash.
Perry	Everard's Coal.....	A.....	.....	1.50	55.50	37.00	7.50	44.50	Red.
Perry	Rock Island seam, upper part	F.....	.....	52.50	54.50	41.00	4.50	45.50	White.
Perry	Rock Island seam, sulphurous parting	F.....	.....	58.00	69.50	27.50	3.00	30.50	Red.
Perry	Rock Island seam, lower part	F.....	.....	50.00	68.50	37.00	4.50	41.50	White.
Perry	Rock Island seam, slaty bottom	F.....	.....	40.50	62.00	34.00	4.00	38.00	Lemon.
Perry	Rock Island seam, Cannel	F.....	.....	45.50	51.50	42.00	6.50	49.50	White.
Perry	Cannelton, upper part.....	F.....	.....	51.50	55.50	41.00	3.50	44.50	White.
Perry	Cannelton, middle part.....	F.....	.....	48.50	50.50	43.00	6.50	49.50	Brown.
Perry	Cannelton, bottom part	F.....	.....	45.50	49.00	46.00	5.00	51.00	Red.
Perry	Clark Bros., upper part	F.....	.....	48.50	50.50	42.50	7.00	49.50	White.
Perry	Clark Bros., middle part	F.....	.....	49.50	53.00	40.50	6.50	47.00	White.
Perry	Clark Bros., bottom part	F.....	.....	48.50	52.50	41.00	6.50	47.50	White.
Perry	Hack's mine, upper part	F.....	.....	49.50	55.50	40.00	4.50	44.50	Blue.
Perry	Hack's mine, lower part	F.....	.....	45.00	53.50	43.00	3.50	46.50	Red.
Perry	McMahon's mine, upper part.....	.....	.....	48.50	52.50	41.50	6.00	47.50	Blue.
Perry	McMahon's mine, lower part .....	.....	.....	50.50	56.00	39.50	4.50	44.00	Brown.
Hancock, Ky....	Hancock mine,* upper part.....	F.....	.....	49.50	53.00	40.50	6.50	47.00	Blue.
Hancock, Ky....	Hancock mine,* middle part.....	.....	.....	45.50	49.50	45.00	5.50	50.50	Brown.
Hancock, Ky....	Hancock mine,* lower part .....	.....	.....	40.00	52.00	41.50	6.50	48.00	Liver.
Hancock, Ky....	Hancock mine,* slaty bottom... ..	.....	.....	38.50	60.50	31.00	8.50	39.50	White.

* These mines are owned and worked by the American Cannel Coal Company, of Cannelton, Perry County.

ANALYSES OF COALS—DUBOIS COUNTY.

COUNTY.	NAME OF MINE OR OWNER.	Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Ashes.	Coke.	Gas.	Water.	Total Volatile Matter.	Color of Ash.
Dubois	Burnham's coal	1.306	81.02	53.00	3.50	56.50	39.00	4.50	43.50	White.
Dubois	Elkin's coal	1.295	80.93	50.50	4.00	54.50	39.00	6.50	45.50	Brown.
Dubois	Harbison's coal	1.198	74.87	23.50	10.00	33.50	60.50	6.00	66.50	Pink.
Dubois	Hay's coal, upper part	1.289	80.66	51.50	3.50	56.00	40.50	4.50	45.00	White.
Dubois	Hay's coal, middle part	1.264	79.00	40.50	3.00	52.50	40.50	7.00	47.50	White.
Dubois	Hay's coal, bottom part	1.271	79.43	51.50	2.00	53.50	40.00	6.50	46.50	White.
Dubois	Kesler's coal, upper part	1.333	83.31	40.00	11.50	51.50	41.50	7.00	48.50	Blue.
Dubois	Kesler's coal, middle part	1.298	79.25	40.50	8.50	49.00	45.00	6.00	51.00	Gray.
Dubois	Kesler's coal, bottom part	1.290	78.75	40.50	9.00	49.50	44.00	6.50	50.50	Brown.
Dubois	Fest's coal	1.305	81.56	48.00	5.50	53.50	41.00	5.50	46.50	Fawn.
Dubois	Bridenbaugh's, upper part	1.273	79.56	52.50	4.00	56.50	37.00	6.50	43.50	Red.
Dubois	Bridenbaugh's, middle part	1.265	79.06	51.50	3.50	55.00	40.50	4.50	46.00	Red.
Dubois	Bridenbaugh's, bottom part	1.246	77.87	52.50	3.50	56.00	39.00	5.00	44.00	Red.
Dubois	Rudolph's coal	1.301	78.81	48.50	4.00	52.50	42.00	5.50	47.50	Red.
Dubois	Joe Stein's coal	1.290	78.75	48.50	3.50	52.00	43.50	4.50	48.00	Brown.
Dubois	M. Wilson's coal	1.416	88.50	53.00	2.50	55.50	40.50	4.00	44.50	White.
Dubois	M. Wilson's coal, (another part of the mine)	1.286	80.37	44.50	3.00	49.50	44.50	6.00	50.50	Red.
Dubois	Adam Smith's, upper part	1.256	78.50	43.50	3.50	47.00	46.00	7.00	53.00	White.
Dubois	Adam Smith's, middle part	1.335	83.43	49.00	2.50	51.50	43.50	5.00	48.50	White.
Dubois	Adam Smith's, bottom part	1.301	78.81	44.50	4.50	49.00	45.50	5.50	51.00	Gray.
Dubois	Bretzville coal	1.275	79.08	49.00	3.50	52.50	43.00	4.50	47.50	White.

ANALYSES OF COALS—PIKE COUNTY.

COUNTY.	NAME OF MINE OR OWNER.	Specific gravity.	Weight of one cubic foot.	Fixed carbon.	Ashes.	Coke.	Gas.	Water.	Total Volatile Matter.	Color of Ash.
Pike.....	Thomas Case's Coal.....L?	1.280	80.00	45.50	4.00	49.50	47.00	3.50	50.50	Fawn.
Pike.....	Bennett's Coal.....K	1.298	79.25	45.50	3.50	49.00	45.00	6.00	51.00	Brown.
Pike.....	Alexander's Coal.....N	1.284	80.25	49.50	3.00	52.50	41.50	6.00	47.50	White.
Pike.....	Alexander's, another part of the seam.....N	1.259	78.60	52.00	4.00	55.00	36.00	8.00	44.00	White.
Pike.....	Dr. Posey's, upper part.....K	1.288	80.50	48.00	5.50	53.50	40.00	6.50	46.50	Blue.
Pike.....	Dr. Posey's, middle part.....K	1.275	79.68	48.00	4.00	52.00	41.00	7.00	48.00	Fawn.
Pike.....	Dr. Posey's, bottom part.....K	1.244	77.75	50.50	6.00	56.50	38.00	5.50	43.50	Brown.
Pike.....	Shandy's, upper part.....K	1.279	79.94	51.50	5.00	50.50	37.00	6.50	43.50	White.
Pike.....	Shandy's, lower part.....K	1.270	79.37	49.00	3.50	52.50	41.50	6.00	47.50	White.
Pike.....	DeBruler's, upper part.....K	1.294	80.87	42.00	5.00	47.00	45.00	8.00	53.00	Blue.
Pike.....	DeBruler's, middle part.....K	1.371	79.43	44.50	5.50	50.00	44.00	6.00	50.00	Brown.
Pike.....	DeBruler's, bottom part.....K	1.268	79.25	50.00	3.50	53.50	40.00	6.50	46.50	Blue.
Pike.....	Crowe's, upper part.....L	1.274	79.68	52.50	3.50	56.00	36.50	8.50	44.00	Fawn.
Pike.....	Crowe's, lower part.....L	1.262	78.87	47.90	8.50	56.40	35.10	8.50	49.80	Gray.
Pike.....	T. Smith's.....N	1.279	79.93	53.90	2.50	56.00	38.50	5.50	44.00	White.
Pike.....	Hawthorn & Gleason's.....L	1.269	79.31	45.50	14.00	59.50	32.00	8.50	40.50	Gray.
Pike.....	Barr's.....M	1.260	76.75	57.00	3.50	60.50	32.50	7.00	39.50	White.
Pike.....	Fall's, upper part.....N	1.274	79.62	47.00	5.00	52.00	42.50	6.50	49.00	Fawn.
Pike.....	Fall's, lower part.....N	1.268	79.25	51.00	4.00	55.50	37.00	7.50	44.50	White.
Pike.....	Owner unknown.....K	1.268	79.25	48.00	3.00	51.00	44.50	4.50	49.00	White.

ANALYSES OF COALS—PIKE COUNTY CONTINUED.

COUNTY.	NAME OF MINE OR OWNER.	Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Adhes.	Coke.	Gas.	Water.	Total Volatile Matter.	Color of Ash.
Pike	De Tar's coal, upper part.....A	1.444	90.25	41.50	14.00	55.50	37.00	7.50	44.50	Red.
Pike	De Tar's coal, lower part	1.288	80.50	49.50	5.00	54.50	40.00	5.50	45.50	Red.
Pike	Bee's coal	1.269	79.31	44.50	14.00	58.50	37.00	4.50	41.50	Brown.
Pike	Moulton's coal, upper part.....K	1.244	77.50	48.00	3.50	61.50	43.00	5.50	48.50	Blue.
Pike	Moulton's coal, middle part	1.257	78.56	50.50	8.50	59.00	36.50	4.80	41.00	Red.
Pike	Moulton's coal, bottom part.....K	1.257	78.56	49.50	3.00	52.50	41.50	6.00	47.50	White.
Pike	Thomas' coal.....K	1.280	80.00	48.50	4.00	52.50	40.50	7.00	47.50	White.
Pike	Wells & Whitman, upper part	1.294	80.87	52.50	2.50	55.00	37.00	8.00	45.00	White.
Pike	Wells & Whitman, middle part	1.278	79.87	50.50	2.00	52.50	41.50	6.00	47.50	White.
Pike	Wells & Whitman, bottom part	1.275	79.68	50.50	2.50	53.00	42.00	5.09	47.00	White.
Pike	Massey's, upper part	1.298	79.25	53.40	3.50	57.00	34.50	8.50	43.00	Gray.
Pike	Massey's, bottom part	1.279	79.93	55.00	1.50	54.50	36.50	7.00	43.50	White.
Pike	Martin's, upper part	1.258	78.62	52.00	3.50	56.50	37.00	7.50	44.50	Gray.
Pike	Martin's, middle part.....L	1.269	79.31	57.00	3.00	60.00	33.50	6.50	40.00	Gray.
Pike	Martin's, bottom part.....L	1.275	79.68	55.00	2.50	57.50	35.00	7.50	42.50	White.
Pike	Tevault's	1.245	77.81	40.50	3.00	52.50	40.50	7.00	47.50	White.
Pike	Wood's	1.272	79.50	46.00	3.00	48.00	47.50	4.50	52.00	White.
Pike	Ingham's, upper part.....K?	1.280	80.00	49.00	2.00	51.00	41.50	7.50	49.00	White.
Pike	Ingham's, lower part.....K?	1.311	81.92	50.50	2.00	52.50	41.00	6.50	47.50	White.

ANALYSES OF COALS.										
COUNTY.	NAME OF MINE OR OWNER.	Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Adhes.	Coke.	Gas.	Water.	Total Volatile Matter.	Color of Ash.
Parke	Sand Creek coal.....	1.294	81.00	45.50	4.50	50.00	45.59	4.50	50.00	Light brown.
Parke	Beard's coal.....	1.101	74.43	48.50	1.00	49.50	42.50	8.00	50.50	White.
Davies	Buckeye Cannel Coal Company, Cannel coal.....	1.229	76.87	42.00	8.00	48.00	48.50	3.50	52.00	White.
Sullivan	Henry K. Wilson's mine	1.228	76.75	51.90	0.80	52.40	45.25	2.55	47.60	White.
St. Joseph	Peat from Notre Dame .....	.....	.....	20.50	0.50	38.00	55.50	8.50	64.00	Yellow.
Spencer	H. B. Kittan's coal	1.244	77.75	46.50	2.00	48.50	47.00	4.50	51.50	White.
Spencer	Kathman's coal, upper part	1.270	78.12	45.50	2.00	47.50	48.50	4.00	52.50	White.
Spencer	Kathman's coal, lower part	1.251	78.18	47.50	2.50	50.50	45.00	5.00	50.50	White.
Spencer	Abbott of St. Meinrod	1.245	79.06	50.50	5.00	55.50	39.00	5.50	44.50	Brown.
Parke	Bethany, Cannel coal .....	.....	.....	43.00	4.50	47.50	47.00	5.50	52.50	White.
Sullivan	Curryville,* upper part .....	.....	.....	56.50	2.50	59.00	36.50	4.50	41.00	White.
Sullivan	Curryville, middle part .....	.....	.....	58.50	1.50	55.00	40.00	5.00	45.00	White.
Sullivan	Curryville, bottom part.....	.....	.....	52.50	3.00	55.50	40.00	4.50	44.50	White.

* Bottom seam.

ULTIMATE ANALYSES OF COALS.

NAME OF MINE OR OWNER.	Ash.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Heat Units.
Sand Creek coal, Parke county.....	4.71	76.38	4.71	1.86	12.32	.....	7208
Sand Creek coal, another specimen....	3.19	77.03	5.60	1.54	12.64	.....	7609
Buckeye Cannel Coal Company, Daviess county.....	7.65	71.10	6.06	1.45	12.74	1.00	7284
Henry K. Wilson's mine, Sullivan county.....	1.66	84.09	3.61	1.80	11.45	1.00	8004
Peat from Notre Dame, St. Joseph county.....	9.50	39.10	4.90	.....	36.00	.....	3203
Garlick & Collins, Clay county, No. 1.....	3.88	76.81	4.13	1.78	12.90	.50	7498
Garlick & Collins, Clay county, No. 2.	1.07	82.70	4.77	1.62	9.39	.45	
Star Mine, Planet Furnace, Clay county, No. 1.....	2.74	80.74	5.61	1.67	8.60	.73	8383
Star Mine, Planet Furnace, Clay county, No. 2.....	2.74	81.60	4.39	1.67	8.87	.73	
Clay Coal Company's mine, Clay county.....	1.68	84.68	4.10	1.35	7.69	.50	8028
Rock Island Coals, upper part, Perry county.....	2.00	79.24	4.61	1.16	12.80	.....	7513
Rock Island Coals, average, Perry county.....	9.50	75.40	4.45	0.95	9.70	.....	7283

COALS TESTED FOR ILLUMINATING GAS.

NAME OF MINE OR OWNER.	Cubic feet of Gas per Pound.	Pounds of Coke.	Carbonic acid and Sulphur.	Water.	Tar and Ammoniac. Liquor.	Candle Power of Gas.
Pioneer Shaft, Curryville, Sullivan county	3.88	.675	.015	.026	.07	15
Pioneer Shaft, Curryville, Sullivan county, second trial.....	3.61	.625	.075	.025	.01	15
H. K. Wilson, Sullivan county.....	3.95	.675	.....	.....	.05	15.7
Rock Island Coal, Perry county, top of seam.....	3.41	.625	.060	.025	.15	.....
Rock Island Coal, Perry county, middle of seam.....	3.50	.725	.025	.....	.25	.....
Rock Island Coal, Perry county, bottom of seam.....	2.62	.625	.....	.....	.15	.....
Rock Island Coal, Perry county, average of seam.....	3.18	.690	.050	.025	.12	.....
Rock Island Coal, Perry county, coal rash.....	3.41	.625	.....	.05	.....	.....

PROFESSOR E. T. COX,
State Geologist of Indiana :

DEAR SIR: Hérewith I submit my report on the Geology
of Dubois and Pike counties.

With acknowledgements due to you for information, assist-
ance and many acts of courtesy,

I am yours, etc.,

JOHN COLLETT.

EUGENE, INDIANA, October 10, 1872.

G E O L O G Y

OF

DUBOIS COUNTY, INDIANA.

Dubois county, Indiana, is bounded on the north by Daviess and Martin counties, on the east by Orange and Crawford, on the south by Perry, Spencer and Warrick, and on the west by Pike; embracing an area of four hundred and thirty-two square miles.

Of this area, about one-tenth is river and creek bottoms, occasionally subject to inundation; one-half modified drift and alluvion of ancient lakes and rivers, the remainder bold hills and elevated plateaus and knolls, underlaid by the conglomerate sandstone.

The surface varies from high hills, on the east, to gently rolling or level plateaus in the southern, southwestern and northwestern parts.

The county is abundantly supplied with water. The east fork of White river chiefly forms the northern boundary, and Patoka river flows from east to west through the center. These, with their numerous branches, ramify into all parts. Many springs flow out at the junction of the alluvium and recent drift with the older deposits, and at outcrops of impervious strata accompanying coal seams.

RECENT GEOLOGY.

The surface deposits of Dubois county consist of clays, slightly intermixed with gravel, or pure, of the glacial drift, and loess with the subsequent lacustrine and alluvial deposits.

The *alluvium* of the river and creek bottoms is an accumulation due to causes now in action, and it is formed from the decomposition and intermixture of sedimentary material from all the older rocks; hence its friability and great fertility.

At a height of from one hundred and ten to one hundred and twenty-three feet above the present low water of White river, on alternate sides and opposite to great curvatures in the general trend of the valley, other ancient alluvial deposits are found—"sand-bars," dating back to the long past, yet as easily identified as the "bars" which mark the "bends" of the present river. Conspicuous examples may be seen east of Haysville, on "Harbison" farm, west of Haysville, at Portersville and many other points in Daviess and Pike counties. It is evident that the *ancient* river was subject to the present laws of flowing water. Gravel and bowlders torn from the most obdurate rocks toward its source formed shallows and obstructions (rapids) then as to-day. One of these ancient riffles, represented by a *bed of geodes* from the mountain limestone of Orange and Lawrence counties, is seen on the hill in the west part of Haysville. A similar bed was noticed on the road to Jasper, south of Portersville, both indicating the wide range traversed by this stream before the present valley was excavated.

Lacustrine deposits are found when digging wells in the level plateau in the northwest part of the county, between Ireland and Otwell. They consist of clays and impalpable intercolations of silicious material, occasionally interrupted by thin layers of quicksand. Near the base of these beds are found remains of shrubs and grape vines of enormous growth, indicating, perhaps, the luxuriance of a warmer clime.

The Loess caps the highest hills of the county. Where
G. R.—13

undisturbed it is a brown loamy sand, imperfectly stratified, twenty to thirty feet in thickness. Rich in plant-food, it is noted as the "*walnut level*." We here find on the highest hill-tops, a growth of timber and plants usually limited to the warm loams of the bottoms; as Walnut, Sugartree, Wild Cherry, Spice Wood, Pawpaw and Bluegrass. Examples may be seen at Harbison's walnut grove, east of Haysville, and near Birdseye.

The greater portion of the loess has, in the course of ages been eroded or modified. The soluble ingredients have been removed, while the residual ash-gray sands and clays are left deposited like a sheet of snow covering the hill sides, and partially filling valleys formed previous to the glacial period. The Patoka river has the features* characteristic of streams flowing through loess deposits. The bluffs slope gently down to the valley "bottoms;" these are of much greater width (ranging from one to three miles wide) than would be expected from the present size of the stream. The soil is cold and impervious to moisture; hence very wet in winter and very dry in summer. The usual timber on these bottoms is Elm, Water Maple and Gum; occasionally a choice tract of sandy bottom, but rare indeed, will exhibit a fair growth of Beech, Sugar, Overcup Oak and Poplar.

The plastic nature of modified loess, covering all the older deposits, and hiding from view the ancient bluffs and valleys, renders difficult the work of the geologist, especially in a county like this where remoteness from lines of commercial transit gives no incentive to local mining.

The Boulder or Glacial Drift is the next in age. It consists of blue and white plastic clays spread out over a system of hills and valleys excavated previously or during an early period of the glacial era. Commencing in the southern part of the county with a depth varying from a few inches to nearly one foot, it gradually thickens toward the north; and along White river it attains a depth of eight feet, with

*See White's Geology of Iowa.

a slight intermixture of gravel not exceeding half an inch in diameter. When exposed to the surface, the lower member of the drift is sometimes mistaken for a fire clay. It will furnish good potters' clay for common crockery.

PALEOZOIC GEOLOGY.

The stratified rocks of this county belong mainly to the coal measures, with a limited exposure of subcarboniferous or mountain lime-stone, in the deep gorges of the head waters of the Patoka river. The entire area of the county is underlaid by coal, excepting only the highlands commencing a short distance north of Birdseye and extending to the northern boundary. Even in this area, occasional out-liers will be found on the hill tops, but of no great extent.

The following general section taken at different points will give a connected exhibit of the coals and rocks.

GENERAL SECTION.
COMMENCING AT THE HILL NORTH OF JASPER.

SPACE.		FT.	IN.	
21.		2 — 10		Soil.
		10		Shaly sandstone.
		1		Black slate.
1.4		1	4	CUAL M.?
20.3		2	3	Fire clay.
		18		Siliceous shales, part sandstone.
1.8		1	8	COAL J.?
67.		9		Fire clay with iron nodules.
		40		Siliceous shales and covered.
		1 — 10		Hard flinty limestone.
		2 — 8		Black slate with iron concretions.
		2	10	COAL K with 2 inches sulphur band.
2.10		1	6	Fire clay, plastic.
		3		Fire clay, hard.
		22		Laminated and ferruginous sand rock.

•GENERAL SECTION—Continued.

SPACE.		Fr.	Is.	
		48	—110	Massive conglomerate.
		24	— 2	Gray siliceous shale.
		0	— 10	8 Calcareous shale.
		0	— 2	2 Bituminous shale.
4		1	— 4	COAL A, part block coal.
		1	— 2	2 Dark bituminous clay.
		3		Blue clay shale.
		7		{ Siliceous shale with carbonaceous { partings.
		2	— 2	2 Bituminous clay shale.
			— 9	9 COAL, rash.
		1	— 6	6 Shaley fire clay.
		4		Clay shale with iron nodules.
		10		Archimedes limestone.
79.		50		Oolitic limestone.
339.	Total.			

RECAPITULATION.

SPACE.		Ft.	In.	
		21		Space.
		1	4	COAL M?
		20	3	Space.
		1	8	COAL L?
		67		Space.
		2	10	COAL K.
		141	4	Space.
		4		COAL A.
		79	7	Space.
	Total.	339		

COAL L AND M.

The division in the foregoing section, from the shaly sandstone to the fire clay inclusive, includes the strata accompanying two small seams of coal on the hill in the northern part of Jasper, the county seat. Although isolated by surrounding valleys, they probably represent coals L and M, here thin and intermittent on account of proximity to the rim of the basin. These seams have been worked by stripping at this point, and thence westerly and northwesterly, toward the neighborhood of Ireland, they are seen at frequent outcrops at the hill tops, and near the surface in the table lands. In all this region, L and M do not attain a thickness sufficient to justify mining, and are of interest only as a horizon from which to estimate the distance, fifty to sixty feet, down to coal K. Observations made in Pike county indicate a probability that near the county line, a few miles southwest from Ireland, coal L may be found not far from the surface with a thickness of three and a half to four feet.

The silicious shales, number eight of the section, often change into flaggy sandstones, and are generally accompanied by a stratum of solid sand rock from two to five feet thick. Leaves and stems of the coal plants *Neuropteris*, *Pecopteris*, *Alethopteris*, *Asterophyllites*, *Flabellaria* (?) and *Cordaite*s were found in the shales of this bed, in the rocky layers; trunks of *Sigillaria*, *Calamites* and *Lepidodendron* are often preserved as casts of wonderful beauty and exactness of detail. This layer furnishes good material for foundations and hammered masonry.

Coal K, of the general section, and the strata, which almost invariably accompany that seam, constitute a marked horizon. Commencing on White river at the north, these strata gradually but irregularly ascend to the summit of this ridge, dividing the waters of White river from those of the Patoka, and then descend to the trough through which flows the latter stream. Thence to the south and east, they mount the conglomerate ridges, often at the rate of 50 feet to the mile, and

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after passing the summit of the divide, (now cut through by Hall's creek, Strait creek and Hunley's creek,) these strata again descend to near the level of the stream, flowing into the Ohio near the southern line of the county. Some of these companion deposits may be absent or not visible, but the appearance of one or more will generally enable the observer to determine with reasonable exactness the position or *place* of the missing series. Thus in the valleys or basins these rocks are generally *all* well developed in regular succession, but as we ascend the sandstone ridges, south, east and north-east from Jasper, and *especially* as we approach the rim of the coal basin, they become thinner. First the coal disappears, then the bituminous shale is no longer found, and finally, high on the hill tops, out-liers of K are seen, if we may use such a contradictory expression, represented by notable fire clay and the flinty limestone roof, but all the carbonaceous material which usually lies between them entirely missing, never having been deposited at these points.

These facts in relation to coal K, and similar observations in relation to the final outcrop of other seams in the vicinity establish, as it seems to me, lines which limit the carbonaceous deposits of each particular seam—fixes an absolute margin to our coal measures, and bears damaging testimony against the theory heretofore advanced, that “the Indiana and Ohio coal fields were once connected by continuous deposits of coal over the central and eastern parts of this State, since removed by denudation.”

The internal evidence recorded by either the coal or the limestones considered separately is no less unorthodox, and shows facts which can scarcely be harmonized with the adopted “bog or swamp” theory for the deposition of coals and coal measure limestones. The latter, in the western part of the county, is generally bituminous, sometimes argillaceous, but often so pure as to admit of being burned for lime. Like other coal measure lime rocks it is filled with fossil shells and casts of animals, which are exclusively of marine origin. Prominent among these are the remains

of the gigantic fish *Edestus vorax* (Leidy), chambered shells as *Orthoceras*, *Nautilus*, etc., etc., of great size, *Spirifers*, *Pleurotomaria*, etc.; all of which, either from peculiar adaptation of form, as the chambered shells, or from delicacy of structure such as the minute ornamentation of the *Pleurotomaria* and the fragile tenderness of the spined *Productis*, indicate a home in the profound and quiet depths of a central ocean, remote from the influence of waves as well as from rocky or sandy bottoms, until some mighty current of disturbed and muddy waters impelled by earthquake action overwhelmed these animals—the impure water putting an end to their life, and burying them in the slimy bed deposited over the coal material. At Jasper, and easterly toward the rim of the basin, this limestone becomes more silicious, occasional fossils, battered and worn by long transportation, are found, which belong to the epoch of the subcarboniferous lime rocks, but coal measure fossils predominating.

Still further east, the silicious matter increases. Masses and bands of flints are found imbedded in this stratum until finally the flints predominate over or take the place of the former rock. Here are found some worn fossils belonging to the coal measures; but with many strictly characteristic of the subcarboniferous age, as *Pentremites* (worn) and their stems, Crinoid stems, plates and arms, and highly ornamented plates and spines of *Archæocidaris*; these last so well preserved as to exhibit the minutest details of ornamentation. Now, these animals, whose home is known to be in the shallow seas which laid down the mountain limestone, could not have lived here. They must have been transported at the time of their death from areas suited to their mode of life, still further to the east, and leave the inference that the seas which sustained these animals of the subcarboniferous age existed within a distance of five to ten miles, at a higher level and contemporaneously with the deposit of coal K. These facts I have not seen noticed elsewhere. I submit them for consideration, and am alone responsible for the heresy, if they prove heretical.

Again, coal K, in the valleys and basins of lower level, is

usually from two and a half to three feet thick. In the western part of the county, it is generally a caking coal. At the center, it is about one-third block coal, the balance caking or semi-block. At some localities, the block coal is in the middle of the seam, at others, within a distance of a few miles; the block coal may be either at the top or bottom, the caking stratum interchanging with it. While caking coals are generally referred to bogs and the peat of swamps for their origin, the accepted theory for the formation of cannel and splinty coals, is that the vegetation from which they are constituted, was first macerated for a long period in sea water, until pulpified and then cast down. This theory is reasonable, and is sustained by the fact that often in such cannels are found the most solid remains of marine animals, as scales, teeth and spines of *Petrodus* and other fishes. We can hardly conceive of a swamp of such versatility of character—so flexible in its nature, as to allow changes of level during the time necessary for the deposit of a single thin seam of coal, sufficient to make these phenomena accord with Lyell's theories. The situation would demand dry land swamps, and sea water deep enough to float fishes from twenty to forty feet long, to interchange with bewildering frequency and with reckless disregard of their order of occurrence. I do not hesitate to question the correctness of Lyell's plan and to believe that theories must be adopted, locating the area of coal deposit in the deep waters of a central ocean.

Returning to the general section, a coarse, black sulphurous slate, with pyritous iron balls, or "bowlders" as they are locally called, is a persistent companion coal "K." It ranges in thickness from two to eight feet, and occasionally is highly bituminous and free from sulphur. The iron balls or pyritous bowlders are almost invariably present, wedged in the slate near its base. They are highly fossiliferous, containing a few fragments of coal plants, but more generally shells and marine animals. From one of these, broken up at Ingham's bank, in the northeast corner of Warrick county, besides more than

twenty species of shell fish, Dr. Rust, of Holland, found a fish bone, some eight inches long, in which was inserted a row of large saw-edged teeth. This fossil has until lately been figured and described as the jaw and teeth of a fish of the shark family of great size, under the name of *Edestus Vorax*, Leidy. Professor Cope, who is an unquestioned authority, unhesitatingly unites with Professor Worthen, in the opinion, that this determination is a mistake; that it is not a jaw-bone and teeth, but that it is the dorsal or caudal armature of a ray fish. This would indicate an animal of great size. The boulder itself was filled with shells, bones, teeth and sulphurous matter, exhibiting just such a preponderance of animal remains as is found to constitute the coprolites often seen in these shales. It is well known that such coprolites are often the nuclei around which the nodules* and iron balls in the coal measures are formed; but this boulder, and its companions, were homogeneous in their texture. The whole rock must be referred to the same origin. If part was coprolitic, the whole was coprolitic as well. If so, we have in these boulders a hint possibly pointing them out as the excreta of wonderful monsters endowed with power and capacity to destroy and digest the gigantic *Edestus* and similar animals. The survey is indebted to Dr. Rust, of Holland, the finder, and Dr. Wellman, of Jasper, for this unique specimen of *Edestus*. Figures pretty well representing it may be seen in Geological Survey of Illinois, vol. iv, page 350. Three other specimens have been found: one in Illinois, one in Posey county and another in Parke county, Indiana; all in the bituminous roof shales of coal.

Seam "K," of the general section, underlies near two-thirds of the western part of the county, it varies in thickness from two to four feet, averaging two feet and a half. Generally it is a caking coal; but, toward the eastern margin, it becomes more or less splinty, and at some localities wholly block coal. Sections hereafter given will show details of this seam in different parts of the county. The supply will be found abundant for home consumption with

* See Dana's Geology.

considerable amounts for exportation if the railway facilities now proposed are ultimately supplied.

The under clays, lying immediately below the coal, are the ancient soil on which the plants rested and lived, which produced this mineral fuel, and whose rootlets (*Stigmaria*) are seen traversing the clay in every direction; it is generally silicious, and would furnish a fair to good article of fire clay. At other points, as the summit of the sandstone hills, a few miles southwest from Jasper, and at Beeler's hill near Huntingburg, this clay is more aluminous, offering a choice plastic clay, well adapted for queensware potteries. The soft laminated sandstone, number fourteen of the section, varies in thickness from ten to fifty feet, and averages about twenty-two feet. Sometimes it changes into a silicious soapstone as at Huntingburg, and occasionally into thin bedded quarry sand rock; but generally it is constant in its characteristics, with a strong tendency to disintegrate. On the higher levels, this stratum is the horizon at which a sheet of water percolated through the porous sandstone, or sand bed, dissolving and taking up the ferruginous constituents, which we now find deposited as iron ore on the brow and sides of the conglomerate hills. These sands probably formed at that era a bluff margin, either to a basin of ordinary water, or else to a basin of waters of a particular specific gravity near whose surface the mineral was deposited.

The massive conglomerate sandstone comes next in the section. It is a prominent feature in the eastern side of the county. Like a massive wall it encloses the true coal basin. From the sides of this wall several spurs are thrown out, one of which continues entirely across the county from east to west, south of Patoka river. This deposit may be characterized as a coarse-grained, ferruginous, massive or heavy bedded sandstone. Occasionally, the upper beds are filled with small pebbles of quartz, jasper, etc., relics of some older age of the ever changing earth's existence. Generally the pebbles, which give the name *Conglomerate* to the forma-

tion, are absent; and, at some rare stations the rock is soft and fine-grained.

Hills from two to four hundred feet in hight, alternate with deep narrow valleys cut out by the wear of small creeks or springs, and which are often bounded by precipitous or overhanging sides. Crevices, now filled with clays and fragments from above, were seen piercing the rock from the top to a depth of more than one hundred and fifty feet, yet hardly exceeding one or two feet in width. Good examples of this kind were also seen at Shoals in Martin county, and at "High Rock" in Daviess county. For their origin we must look to oscillations in the earth's crust—a gentle earthquake parting. They were probably the primal agency which called into existence many of the valleys and gorges which so often cross the ridges and spurs of this rock in a straight line, utterly disregarding the level of the adjoining table lands.

From the coarseness of the materials (coarse sand and pebbles) we know that the Conglomerate was borne to its place of deposit by strong currents of water, and, from false bedding of the strata, that the current was subject to changes of direction, by erosive cross-currents. In these waters floated many of the coal plants. The leaves and delicate plants were worn or destroyed by the angry waves; but trunks of *Sigillaria*, *Stigmara*, *Lepidodendron* and *Ulodendron* are common, the casts sometimes preserving their beautiful markings with wonderful delicacy. At some points balls, cylindrical rolls, and pellets of coal were observed near the base of this rock; showing that coal material, perhaps, torn from some regular seam while yet soft and plastic, had been rolled along with the moving water until moulded by its action into the forms most likely to be produced by such a state of affairs, then bedded down, to be changed to coal by pressure and time.

Just beneath the massive sand rock, the gray silicious shales, of the section, are found varying from two to twenty-four feet in thickness. Carbonaceous and pyritous partings, and plant remains abound. On

exposure, this shale decomposes, rendering the stratum friable, and forming soluble salts. This material is carried away by the creeks and winter torrents, while the massive rock above remains. Thus are formed the "rock houses," and "pot houses" so frequently seen in this region.

The calcareous shales sometimes changing into limestone, are pretty constant, but sometimes absent. Generally shaley and so unimportant as to scarcely merit notice, yet when hardened into lime rock they form a notable feature. On King's farm, near Birdseye, this limestone is largely thickened up, and underlying shales come in of considerable depth. This, and a few other exposures noticed near Schnellville, and in the southeast part of the county, are exceptions to the general rule.

Coal A, of the section, is almost invariably capped with a black, highly bituminous slate, generally inclosing some pyritous iron stones. Small developments of cannel coal were occasionally noticed in this slate; and, although not thick enough at any of the exposures to be of practical value, yet, from the existence of this kind of coal at neighboring localities in Daviess, Pike and Perry counties, we may expect its discovery hereafter in valuable bodies. Seam A, under-runs the whole county, except the highest conglomerate ridges on the eastern border. It varies in thickness from one to four feet, averaging about one foot and two inches. A reference to the Chemist's report will show that it is rich in carbon. This tends to equalize the fuel value of this with thicker seams; for it will be found more economical to mine the same amount of combustible material (carbon) from a thin seam than from one of much greater size. The coal is compact, generally splinty, of vitreous lustre, conchoidal fracture and so free from charcoal dust as to make it pleasant and desirable for parlor use, as well as for that of the iron master.

At a distance of from twelve to eighteen feet below, a thin seam of brash coal was seen at several exposures. It is not persistent, and was not found to exceed nine inches in thickness, and often a mere trace. When the materials

from the Blue clay shale to the clay shale with iron nodules inclusive, are absent, they have been eroded, by currents of sufficient power to transport the coarse sands which now replace these strata with heavy sand rock at a few localities, and form the base of the conglomerate.

The subcarboniferous or mountain limestone county is exposed in this county only along the streams. The head waters of Patoka have cut their deep, narrow valleys through the conglomerate, bringing to view the underlying rocks on Davidson's creek, Cane creek, Lick fork, and Patoka river. Quarries have not been opened in this bed, and the precipitous sides of the valleys are generally covered with fragmentary debris from above, so that good sections could not be obtained. No well preserved fossils were found, but the spirally-turned stems of *Archimedes*, with *Pentremiles* of several species, were common in the upper member (number 27 of the section.) Below, some fifty feet of light colored oolitic stone was seen, which furnishes choice white lime. As usual, large springs burst out from these rocks, some of which are accompanied by a great volume of cold air, indicating a cavernous opening within the hill. A notable example on the Burton farm, section 22, township 1 north, range 3, is worthy of a special mention.

In the foregoing discussion of the general section, I have given a summary of the geology of this county sufficiently complete for the requirements of the student and general reader. To this will be added sub-sections from different parts, selected as most characteristic of each particular neighborhood, giving details for local information.

LOCAL DETAILS.

That part of the general section commencing at the sandstone, below coal K, and measuring up to the highest known strata, was taken in the town of Jasper, and on the hill to the north. A repetition is unnecessary. Coal K here averages two and a half feet in thickness, and is

fully one-half block coal. It has long been worked for local use, but, for want of transportation, to no greater extent. Samples comparing favorably with the Clay county coals were selected for the State Cabinet. The upper seams L? and M? have been worked by stripping. They are also found in the hills west of town, and north on the Portersville road. Along the road to, and at Ireland, several outcrops either of the coals or of their more enduring under-clays were observed. Near their final outcrop the coals are here thin, as well as impure, and will never probably be found to be of any practical value. Many of the under clays are highly plastic, and would furnish good potters' clay.

West of the thriving village of Ireland, for miles, a perfectly level plateau of ancient lacustrine alluvium is spread out, which covers the lower workable coals. This plateau, one hundred and twenty feet above White river, is walled, on the side towards the north by gentle bluffs, often of sand, from twenty to twenty-five feet above its level, analogous to the "coast" or levee embankment of the Mississippi, for the ancient river which once flowed here.

Going south, seam K is reported visible at low water on Egg's land, southwest quarter section 35, township 1 south, range 5, of a good quality, splinty fracture, and three to three and a half feet thick. The bank was not opened. This was also the case as to coals reported three feet thick on Kato's and Heif's land. South of Jasper, at Gerber's, near center of section 1, township 2 south, range 5, considerable coal has been mined for blacksmiths' use.

SECTION AT GERBER'S.

Soil.....	.....
Sandstone.....	12 ft. 0 in.
Shaly sandstone.....	4 ft. 0 in.
Limestone with flints.....	2 to 3 ft. 0 in.
Calcareous shale.....	1 ft. 2 in.
Black bituminous shale.....	1 ft. 0 in.
Silicious and pyritous shale.....	2 ft. 6 in.
Coal K.....	2 to 3 ft. 6 in.
Fire clay.....	.....

 27 ft. 2 in.

The coal was not being worked, only weathered samples could be obtained; and these were rather too sulphurous for comfortable use. The limestone above K, is interrupted by layers of flint from two to five inches thick. Attempts to burn for lime have consequently failed.

Descending the Patoka, at Spaur's mill, banks have been opened, and also on the land of A. Smith. This coal, judging from weathered specimens, is a fair caking coal, and is three feet ten inches thick.

At Keshner's mill, northeast quarter, section 18, township 2 south, of range 5, the strata are thrown up, showing the heavy bedded sandstone above the conglomerate near the water level. Fifty feet above, the limestones accompanying K, are seen on the hillside in great blocks or heavy bands.

SECTION AT KESHNER'S MILL

Limestone with <i>Productus semireticulatus</i> , <i>P. punctatus</i> , <i>Spirifer cameratus</i> , <i>Athyris subtilita</i> , <i>Pinnæ</i> and Crinoid stems.....	8 ft. 0 in.
Covered.....	20 ft. 0 in.
Coal K.....	2½ to 1 ft. 0 in.
Fire clay.....	4 ft. 0 in.
Soapstone with iron nodules.....	2 ft. 0 in.
Silicious shales and sandstone.....	16 ft. 0 in.
Laminated and heavy bedded sandstone.....	12 ft. 0 in.
Patoka river.....	.....

 63 ft. 0 in.

Near by, in sections seven and eighteen, obscure outcrops of K were noticed in the beds of branches, but without opportunity of measurement. A very choice specimen of gas coal was picked up in a branch on the Green farm.

On Samuel Dillon's farm, sections five and eight, same town and range, coal has been mined to supply demands for grate and blacksmiths' use; and the well developed limestone has supplied the local market with lime, quantities of which was being used in building the new Catholic church at Jasper. With much difficulty the following section was obtained:

SECTION AT S. DILLON'S.

Covered.....	50 ft. 0 in.
Sandstone and silicious shales.....	20 to 30 ft. 0 in.
Limestone with <i>Productus punctatus</i> , <i>P. semireticulatus</i> , <i>P. costatus</i> , <i>Spirifer cameratus</i> , <i>S. lineatus</i> , <i>Athyris subtilita</i> , <i>Myalina</i> , <i>Discina</i> , <i>Cyrtoceras</i> , <i>Nautilus</i> , <i>Conularia</i> , <i>Pleurotomaria</i> , <i>Macrocheilus</i> , <i>Pecten Indianensis</i> , and	
Crinoid stems.....	8 ft. 0 in.
Covered and sandstone.....	15 ft. 0 in.
Gray and blue silicious shales.....	12 ft. 0 in.
Coal K:	
Semi-block.....	9 in.
Good block.....	8 in.
Caking.....	1 ft. 4 in.
Dark fire clay.....	2 ft. 9 in.
	5 ft. 0 in.
	122 ft. 9 in.

Coal on section six, immediately west, Mr. Rothert reports as being two feet thick, and as burning entirely up, leaving but a small quantity of pure white ash.

Going north to White river, coal K has been worked at McCain's and Alcorn's in sections thirty-six, twenty-five, twenty-six, and at Lemmon's, section twenty-four. It is of fair quality, but somewhat sulphurous.

SECTION NEAR MCCANE'S, TOWNSHIP 1 NORTH, RANGE 6.

Cherty limestone.....	8 to 10 ft. 0 in.
Thin bedded sandstone.....	12 ft. 0 in.
Silicious shale.....	3 ft. 0 in.
Soft bituminous shale.....	0 ft. 8 in.
Coal K.....	4 to 3 ft. 1 in.
Fire clay.....	3 ft. 6 in.
	90 ft. 3 in.

Coal A is seen in the bed of White river, on section twenty-four, here brought up by a ridge or hill of the olden time. Across the river in Daviess county, one hundred and twenty feet above, are relics of the cherty limestone roof of K. Intermediate, a perpendicular or projecting wall of conglomerate overlooks the valley. Riven by a crevice from top to bottom, and bruised by storm and flood, it bears strong testimony to the good quality of the rock, and furnishes a section of great interest to the geologist. (See general section numbers 14 to 24, inclusive.) The fine sands within the heavy roofed "rock houses" were filled with small funnel shaped depressions. They were the trap like homes of the ant lion.

In the neighborhood of Portersville, coal K crops out on almost every hillside, and where not visible, its position is at once indicated by the cherty limestone, which so constantly accompanies it. It has been worked for years to supply the village mill, as well as for smiths' use throughout all the neighboring region. A portion of the seam is especially sought after for the latter purpose.

Outcrops or openings were visited on the lands of Snare, Osborn, Graham and the Steam Mill Company, on sections 19, 20 and 21, township 1 north, range 5, where the average thickness was about three feet. The quality was found satisfactory for steam and smiths' use.

The following measurements on John Harris' farm, east of Portersville, gives a fair exhibit of the rocks in this vicinity :

SECTION EAST OF PORTERSVILLE.

Silicious shales and covered.....	
Silicious lime rock with chunks and layers of chert and "tripoli".....	5 to 10 ft. 0 in.
Calcareo-magnesian shale, ferrugin- ous.....	3 to 2 ft. 0 in.
Flinty limestone.....	4 ft. 0 in.
Silicious shales.....	12 ft. 0 in.
Bituminous slate.....	3 ft. 0 in.
Coal K :	
Rich gas coal.....	1 ft. 2 in.
Parting	0 to 4 in.
Semi-block.....	1 ft. 10 in.
	3 ft. 4 in.
Fire clay.....	2 ft. 0 in.
Sandstone and conglomerate.....	35 ft. 0 in.
Water level.....	
	71 ft. 4 in.

For analysis of different parts of this seam I refer to the Chemist's report.

The limestone of the general section is here greatly thickened up, and becomes highly silicified, or changes more or less into chert, with cavities filled with silicious material, which has been used for the manufacture of an excellent polishing powder substituted for tripoli.

Bridenbaugh's coal, section twenty-seven, is also highly esteemed; it is overlaid with beds of black bituminous shale from three to eight feet thick. The adjoining stream, Mill creek, has cut a valley through the coal and these shales; hence a large admixture of bituminous matter in its alluvial bottoms. Decomposition sets free inflammable gases; combustion is produced on contact with the air and, according to the mode of escape, forms jets or balls of fire. Often two or more of the latter have been seen at one time traversing the valley with the uncertain motion of the wind, and with

a brilliancy reported as equaling the head-light of a locomotive. The superstitious believe them to be the wandering ghosts of persons who have been drowned in the stream.

The following measurements, taken on James Harbison's land, northwest section 26, township 1 north, of range 5, give another view of the space from K down to coal A :

SECTION AT HARBISON FARM.

Ancient alluvium.....	20 ft. 0 in.
Ancient riffle-flints and geodes.....	30 ft. 0 in.
Coal K, block (reported).....	2 ft. 2 in.
Thin bedded sandstone.....	5 ft. 0 in.
Massive conglomerate.....	50 ft. 0 in.
Silicious and pyritous shale.....	2 ft. 1 in.
Black bituminous shale with carbonaceous partings.....	1 ft. 2 in.
Coal A :	
Choice cannel.....	0 ft. 3 in.
Choice bright coal.....	1 ft. 4 in.
	————— 1 ft. 7 in.
Stigmarial fire clay.....	4 ft. 8 in.
Silicious shale, bituminous partings.....	15 ft. 6 in.
Silicious iron ore.....	2 in. to 8 in.
Silicious shale and flaggy sandstone.....	5 ft. 6 in.
Low water of White river.....	.....
	—————
	128 ft. 3 in.

In this section, the alluvial sands one hundred and twenty-eight feet above White river are too coarse and pebbly for loess. We can only refer their origin to the high water line of the adjoining stream then flowing at a level nearly one hundred and ten feet above its present channel. As before mentioned, a bed of flints, pebbles and geodes, mostly derived from the mountain limestone of Orange and Lawrence counties, is found in this deposit immediately below the sand ; other riffles containing like materials are seen south of Portersville, and on the hill in the western part of

the village of Haysville, at an average elevation of about one hundred and ten feet above the present level of White river. The sand bars are more continuous, following the river bluffs for miles, where not eroded by creeks cutting through to the river, at an elevation of one hundred and thirty feet above low water in the northeast part of the county, but, in traversing the county from east to west, approaching to within one hundred and eighteen feet of the river, and showing that the ancient stream had more fall than the present river, unless the channel was more tortuous.

The region about Haysville has been subject to severe denuding forces. Coal K has been principally removed. A is seen at the foot of all the hills beneath the massive sandstone. For local purposes, coal has been mined by Potts, near Wolf creek, reported to be of good thickness. Near the mouth of this creek, at "Rock House" Ford of White river, Col. Edmonston, found part of a *Mastodon* skeleton. One of the teeth was presented to Dr. Owen when State Geologist, and is probably in the University cabinet.

Near Kellersville, coal K, near its eastern bounds, is thin or not present. The flinty limestone, with *Spirifer camera-tus*, *Productus semireticulatus*, etc., etc., is met on the hill-tops, indicating the place of the coal, at an elevation of two hundred and fifty-five feet above White river. At Portersville, it is forty feet above the river. By subtraction, we find that K dips two hundred and fifteen feet or twenty-seven feet to the mile going west. Banks were formerly worked in sections 20, 22, 23 and 27, township 1 north, range 4, west, on the lands of Frederic Theruff, John Light and Washington Noble. The thickness was reported at from two to three feet, and the quality fair to choice for smiths' use.

At localities heretofore mentioned, the "conglomerate" is a massive, coarse, ferruginous sand rock. Here, for the first time, we find small pebbles, which become more numerous and of larger size to the east and north, and approach somewhat to the typical form, from which the name is derived. Iron ore was noticed on the hill-top west of Ludlow, some, although silicious, of good quality.

Davidson creek enters the northeast corner of the county, and, nearly in a straight line, flows in a southwesterly direction to a junction with Patoka river. On account of directness and easy grades, the banks of this creek have been selected as the route for the proposed "Rockport and Cincinnati Railway." The creek has cut a deep narrow valley down to the base of the conglomerate, and, near its sources, sixty feet below, into the solid limestone underlying.

Coal A has been formerly worked at the following localities, producing samples of compact heavy coal, with bright resinous lustre, and splinty fracture, and very rich in carbon:

Elkin's bank, southeast quarter, Sec. 29, T. 1 N., R. 3 W.
Burnham's bank, northeast quarter Sec. 28, T. 1 N., R. 3 W.
Burnham's bank, southwest quarter Sec. 21, T. 1 N., R. 3 W.
————— bank, north half Sec. 21, T. 1 N., R. 3 W.
Nicholson's bank, northwest quarter Sec. 23, T. 1 N., R. 3 W.
Harrison's bank, at southeast corner Sec. 14, T. 1 N., R. 3 W.

The openings were for local blacksmiths' use only, and were made by stripping. The coal where seen was from twelve to fourteen inches thick. Dr. E. H. Sabin who is one of the directors of the Rockport and Cincinnati Railroad, has been making explorations since my visit, and informs me that he has found at several points, coals ranging from three to four feet in thickness.

Iron ores were met at several localities marked on the map. The "pot" or "pipe ores" are very pure, and where found in sufficient quantity the quality will prove satisfactory. Ochreous and silicious ores are more plentiful, but leaner. The latter will only be useful to mix with the richer ores of Michigan and Missouri.

In this valley, silicious shales generally fill the space between coal A and the limestone. At some stations they are replaced by solid massive sandstone, resting unconformably upon the latter, and containing many stems and trunks of coal plants, nearly all worn beyond recognition by the friction of coarse material, excepting only *Stigmaria*, *Calamites* and a very few specimens of *Lepidodendron*.

The lime rock hollowed out by the creek is the upper member of the mountain limestone, but was so covered by the talus from the superimposed sandstone as to afford meager opportunity for study. The fossils were worn and broken. No good specimens were obtainable. The following were noticed: *Pentremites* (2 sp.), Crinoid stems, plates and arms, *Terebratula*, Bryozoans (3 sp.) and *Archimedes*. The lower oolitic member, fifty feet in thickness, is the lowest and oldest exposed formation in the county, and consists almost entirely of wave worn, crushed remains of shells, corals, crinoid stems, etc., pure and of a white "stone color;" this will prove desirable for quarry purposes as well as for burning into lime, when the projected railroads furnish transportation. In fact this valley abounds with choice building material which are especially wanted in the counties to the west and southwest. To the agriculturist, the ample and cheap supply of lime which may here be obtained will be a blessing.

A bed of choice glass sandstone was noticed on the land of Wm. Hoggett, northeast quarter northwest quarter, section 17, township 1 north, range 2 west, near the county line in Orange county. On exposure to the air, it disintegrates and becomes white and will prove an important article of trade.

During my stay in this part of the county I was indebted for hospitality, information and guidance to the Hon. Leroy Cave. His intimate acquaintance with localities made his assistance especially valuable.

Other exposures by denudation of the mountain limestone are reported on the head waters of Patoka and its affluents, commencing near the east side of section 4, township 1 south, range 3 west, and extending thence easterly to the county line. Time did not admit of an examination of this locality, but undoubtedly the exposures seen in the Davidson creek valley are here repeated.

Township number one south, range three west, is underlaid by the massive conglomerate, the thickness here ranging from fifty to ninety feet. The surface is moulded

into mighty hills by erosion of branch and creek valleys. These ravines occasionally cut down to coal A, which has been worked to a small extent at Elm Lick Bank, on the land of E. McMillan, northwest quarter section 8, township 1 south, range 3 west, with a reported thickness of two and a half feet, and at Coal Lick Bank, on W. Williamson's land, west half northeast quarter section 6, township 1 south, range 3 west, where it is twelve to fifteen inches thick. Fair specimens of silicious and ochreous ore of iron was found on sections five, six, eight, nine and seventeen, same town and range.

At the east end of the mill-dam at Knoxville were noticed the following fossils, *Lepidodendron* (3 Sp.), *Sigillaria* (2 Sp.), *Alethopteris Serlii*, *Cordaïtes borassifolia*, and *Calamites*; in the bituminous lime rock, *Spirifer cameratus*, *Athyris subtilita*, *Productus costatus*, a *Rhynchonella*, and a *Phillipsia*.

In that part of township number one south, range number four, on the south and east side of Patoka, the conglomerate ores of iron are more abundant. Good to fair surface exposures were noticed on the following farms, viz.:

Stevenson, north half section number 16.

Dudine, southwest quarter section number 15.

Brochman, northwest quarter section number 22.

Brocemar, northwest quarter section number 22.

Breitweiser, northeast quarter section number 29.

Unaway, northwest quarter section number 28.

At many of these localities "pipe" or "pot" and ochreous ores were of rather superior quality, especially at the hill southeast of Riley's mill, locally known as the "Iron Mountain." At all these points the quantity of ore I fear is limited. This fact can be settled by excavation only.

Coal K has formerly been worked to a small extent at Fecher's, section 20, Herbig's and Krass', section 29, and at Snyder and Friedland's, section 31, all township 1 south, range 4. The banks had fallen in, and no opportunity of measurement was afforded. The thickness was



reported at two to two and a half feet. Powel and Stein's bank, section 23, same township and range, was visited under the guidance of Dr. Stevenson. The roof had fallen in; a few fragments found indicated a good smithing coal. In the compact under-clay, we saw casts of *Stigmara*, *Fucoides*, showing the bark between the bud pits beautifully ornamented with lines arranged in concentric rings around the pits. The spirally twisted spines or rootlets were in good preservation.

At Jasper, coal K is seen at low water. Going east, the surface presents a succession of valleys and hills gradually increasing in height until at the east line of the county it attains an elevation of four hundred feet above Patoka river. The coal rising at the rate of fifty to seventy feet per mile soon mounts to the surface, and thence to the east the more persistent limestone roof can still be seen, indicating the place of the seam; the coal itself being no longer present.

These flints were common near V. Beitz's, sections 35 and 36, township 1 south, range 4 west, accompanied by a considerable quantity of ochres of many colors. Immediately below was seen the red sandstone, the level at which the silicious iron stones are found, supported by the massive conglomerate sixty to one hundred feet thick.

Near Celestine, coal A has been worked on the following lands, affording a fair article of steam coal, but generally with some sulphur present:

Schneider's, northeast quarter Sec. 35, T. 1 S., R. 4.

Kish's, northeast quarter Sec. 4, T. 2 S., R. 3.

A. Kish's, northwest quarter Sec. 4, T. 2 S., R. 3.

Hawhee's, northwest quarter Sec. 3, T. 2 S., R. 3.

These banks were not in work, and were reported to range from two to three feet in thickness.

Near the last mentioned banks a coarse, disintegrating white sand rock was noticed, which would furnish a fair article of glass stone. Going southward along Prechtel branch this stratum was seen at intervals, but frequently

the material was fine and well compacted, as on sections 15, 16, and 22, where the glass-rock and grits suitable for grindstones often change into a heavy bedded deposit of beautiful snow-white sand rock. This is valuable, and will be sought after for door and window caps, and ornamental coping and cornice work of first class city buildings. Having a capacity to withstand great heat, this stone will be found especially desirable in buildings sought to be made fire-proof.

The following section was taken on Mrs. Conly's land, east half southeast quarter section 16, township 2 south, range 3, near the foot of the hill:

SECTION AT CONLY'S.

Slope .....	.....
Massive red conglomerate	47 ft. 0 in.
Coarse red sand rock, with many <i>Sig-</i> <i>illariæ</i> and <i>Lepidodendra</i>	8 ft. 0 in.
White sandstone.....	10 ft. 9 in.
Hard, fine snow-white grit and orna- mental rock.....	7 ft. 0 in.
Limestone, coarse, silicious, with <i>Dis-</i> <i>cina</i> , <i>Spirifer cameratus</i> , <i>Productus</i> <i>costatus</i> , etc., etc.....	10 to 4 ft. 0 in.
Covered.....	12 ft. 0 in.
Coal A.....	1 to 2 ft. 0 in.
Fire clay.....	2 to 4 ft. 0 in.
94 ft. 0 in.	

On Hall and Prechtel creeks strong springs (brackish) often break out at the foot of the hills. Almost invariably they may be taken as an indication of coal, as they flow out above or below impervious strata connected with seam A.

In the vicinity of Schnellville no mines were being worked. Outcrops were observed, or openings had been made, at the following localities, viz :

McIntyre, north half Sec. 18, T. 2 S., R. 3 W.
 Burnham, southwest quarter Sec. 14, T. 2 S., R. 3 W.
 Cooke, northeast quarter Sec. 14, T. 2 S., R. 3 W.
 Hanger, northeast quarter Sec. 15, T. 2 S., R. 3 W.
 McCarthy, east half Sec. 16, T. 2 S., R. 3 W.
 Conly, S. E. quarter S. E. quarter Sec. 16, T. 2 S., R. 3 W.
 Conly, south half Sec. 20, T. 2 S., R. 3 W.
 Main's, southeast quarter Sec. 21, T. 2 S., R. 3 W.
 Shoulder, north half Sec. 21, T. 2 S., R. 3 W.
 Atkins, north half Sec. 21, T. 2 S., R. 3 W.
 Grant, west half Sec. 22, T. 2 S., R. 3 W.

The above coals are from one to two feet, rarely exceeding eighteen inches in thickness, and of fair quality. Kidney and ochreous iron stones occur on sections nine, fourteen, twenty and twenty-two; the ochres have been used for painting houses and barns, the colors prove brilliant and durable.

Two miles and a half south of Schnellville, and on the line of the proposed Louisville and St. Louis Railroad, coal A becomes of good thickness. J. D. Hays' bank was being worked, affording a compact, splinty-cannel coal free from sulphur, of a bright vitreous lustre almost as clear as anthracite, and equal if not superior to any other western coal. For analysis I refer to the Chemist's report:

SECTION AT J. D. HAYS' BANK. (WEST HALF NORTHWEST QUARTER SECTION 33, TOWNSHIP 2 SOUTH, RANGE 3 WEST.)

Slope.....	15 ft. 0 in.
Massive sand rock.....	20 to 40 ft. 0 in.
Yellow ferruginous sand rock.....	15 ft. 0 in.
White sand rock.....	12 ft. 0 in.
Soapstone.....	2 to 15 ft. 0 in.
Argillaceous and Calcareous iron stones.	1 ft. 6 in.
Blue shale, pyritous.....	3 ft. 0 in.
Black shale.....	2 ft. 6 in.

Coal A :	
Slaty cannel.....	0 ft. 3 in.
Bright splinty cannel.....	2 ft. 4 in.
Coarse block.....	0 ft. 8 in.
	3 ft. 3 in.
Fire clay.....	3 ft. 0 in.
Shaly sandstone.....	10 to 15 ft. 0 in.
(Continued from a neighboring point :)	
Black and blue bituminous shales.....	12 ft. 0 in.
Rash coal.....	0 ft. 2 in.
Fire clay.....	2 ft. 0 in.
	139 ft. 5 in.

This seam is not thick, compared with those of other regions ; yet, when the large proportion of carbon in a condensed form, the freedom from dust and other offensive admixtures, and the handsome appearance is taken into consideration, its value and importance becomes at once apparent. Desirable for parlor use, it will work not less satisfactorily in the blast furnace. An opening of the same seam on the Weidenboner farm, northeast quarter section 33, made by George Laughbemies, showed thirty-two inches of coal nearly equal to that of the Hays' bank.

LIST OF OPENINGS NEAR HAYS'.

J. D Hays, northwest quarter Sec. 33, T. 2 S., R. 3 W.
 Wash. Chandy, southwest quarter Sec. 33, T. 2 S., R. 3 W.
 Dr. Railing, N.E. quar. N.W. quar. Sec. 33, T. 2 S., R. 3 W.
 Joe. Weidenboner, N. E. quarter Sec. 33, T. 2 S., R. 3 W.
 E. Able, jr., southwest quarter Sec. 28, T. 2 S., R. 3 W.
 E. Able, sr., northwest quarter Sec. 34, T. 2 S., R. 3 W.

These mines will average about three feet of good coal.

Going east from the Hays bank, the highway passes over a succession of ridges from two hundred and fifty to three hundred feet above the Patoka at Jasper, and ascends at Birdseye to the most elevated point visited in the county,

four hundred feet above the Patoka and eight hundred and seventy-five feet above the ocean.

The "massive" band of sandstone is here very compact and widens to a thickness of from fifty to one hundred feet. In it are seen rolls and sporadic sheets of coal of small extent, while more regular seams, subject to currents strong enough to transport the coarse material of which the sandstone is composed, are frequently interrupted by erosion or paucity of material. Beneath the massive sand rock are well developed beds of prytous shales, which, on exposure to the atmosphere, decompose and melt away, while the mighty stratum above still remains, forming "rock houses" under which droves of animals and whole tribes of Indians have been known to take shelter from the snows and storms of winter. From the precipitous face of this roof, large blocks of stones have fallen, which no doubt served to ward off winds and drifting snows, and at other times as seats and lounges for our barbaric predecessors. In these blocks cylindrical cavities, having a depth of from six to twenty inches and a diameter of about five inches, are found. Perfect in form and apparently showing design in their construction, they are locally known as "Indian mortars," for grinding corn and roots. They may possibly have been used for this purpose but their origin is probably due to natural causes.

Seeking shelter from a passing shower in one of these houses, I noticed a small stream of water falling upon the flat surface of the block of stone upon which I was seated. A few tiny pebbles from the conglomerate above were collected in small depressions and kept in constant motion by the dropping water. Thus drops of water and shot-like pebbles were drilling basins down into the solid rock. This experience was afterwards repeated at other localities.

Knolls of loess cap the highest hills, furnishing a rich loamy soil, which produces poplar, maple, spicewood, paw-paw, and other shrubs indicating an alluvial soil. This deposit is from twenty to forty feet thick in the north half section 25, township 2 south, range 3 west.

Near Birdseye, seam A has been opened at the following

places, furnishing a fair to good article of coal, in thickness varying from eighteen inches to three feet and averaging twenty inches, viz.:

D. Pruitt's, N. W. qr. S. W. qr. Sec. 24, T. 2 S., R. 3 W.

T. King's, northwest quarter Sec. 25, T. 2 S., R. 3 W.

J. King's, northeast quarter Sec. 25, T. 2 S., R. 3 W.

Coal Spring, N. E. qr. N. W. qr. Sec. 26, T. 2 S., R. 3 W.

Ab. Pruet's, northwest quarter Sec. 26, T. 2 S., R. 3 W.

A stratum of bituminous limestone eight to twelve feet thick was visited on southwest quarter of southwest quarter of section 24, and northeast quarter of section 21, township 2 south, range 3 west. It was about the level of coal A, but connection could not be seen. It contained *Productus costatus*, *Spirifer cameratus*, *Athyris subtilita*, and plant remains.

Good ores of iron were noticed on the farm of S. Pruet, southwest quarter section 23, township 2 south, range 3 west. Upon completion of the railroad near, this deposit will merit exploration.

In Crawford county, three to four miles northeast from Birdseye, coal A is found on the farms of P. Newton, Mr. Dewitt J. B. King and Lewis Morgan, reported to have an average thickness of two feet.

The north half of township 3 south, range 3, presents a succession of hills, sometimes rounded by circular ravines into the form of pretty regular cones. One of these was found on measurement to be two hundred and fifty feet high, and capped with loess loam. Half way down the side flinty limestones and ochreous and kidney iron ores indicate the place of seam K, here at its easterly margin not endowed with coal. Below are the different members of the conglomerate sandstone, with the massive division, at places widened up to a thickness of over one hundred feet, At the foot of the hills, many strong springs burst out, with waters impregnated with salt, sulphur and iron. They are regarded as a pretty sure indication of coal or of the imper-

vious strata accompanying seam A. Wood is abundant. There is no demand for coal, and none dug or looked for.

Out-crops occur on sections number 2, 3, 6, 7, 16, 17 and 18. No work was being done. No measurements could be secured. The reported thickness ranged from two to four feet with an average over three feet.

Going westward from Schnellville, we find a heavy ridge of massive sand rock projected into the coal basin. It is cut across by Hall's creek, Strait creek and their branches, and divided into a succession of hills or peaks from two to three hundred feet high. The upper portion of these is often covered with loess, or under clays and remnants of the flinty limestone roof of coal K. The soil of the lower knolls and valleys, composed of the pulverized debris quarried from the coal measures and mountain limestones by powerful currents flowing from the east at the close of the glacial period, is a sandy loam and often of a reddish tint from the presence of ferruginous matter derived from the subcarboniferous iron ores. Pears and other tender fruits may be grown here at great advantage. A fine grove of chestnut trees is found on sections 14 and 23, township 2 south, range 4 west. Another on section 13, laps over into section 18, township 2 south, range 3 west.

At St. Anthony, seam A is worked to supply A. Kesler's steam mill. It is here well developed, ranging in thickness from three to four and a half feet, and averaging three feet seven inches. The coal is of good quality; the middle division bright, lustrous, compact, splinty cannel, rich in carbon, and will probably answer for all purposes for which block coal is needed.

SECTION AT KESLER'S, ST. ANTHONY.

Slope covered.....	.....
Ferruginous sandstone.....	20 ft. 0 in.
Massive conglomerate	20 to 40 ft. 0 in.
Sandy shale	8 to 10 ft. 0 in.
Black bituminous clay shale.....	3 ft. 0 in.

Coal A:

Pyritous slaty coal.....	0 ft. 3 in.
Cubic coal.....	3 in.
Compact splinty coal.....	1 ft. 3 in.
Slaty cannel.....	5 in.
Caking coal	1 ft. 0 in.
Rash coal, sulph. balls.....	0 ft. 9 in.
	————— 4 ft. 0 in.
Fire clay	4 ft. 0 in.
Ferruginous sandstone	5 ft. 0 in.
	—————
Total.....	86 ft. 0 in.

Out-crops and old openings are seen at the following points, viz.:

Reed's, northwest quarter Sec. 13, T. 2 S., R. 4 W.
 Klein, northwest quarter Sec. 24, T. 2 S., R. 4 W.
 Miller, northeast quarter Sec. 23, T. 2 S., R. 4 W.
 Kunkle, northwest quarter Sec. 25, T. 2 S., R. 4 W.
 Cox, northwest quarter Sec. 21, T. 2 S., R. 4 W.
 Cox, northeast quarter Sec. 21, T. 2 S., R. 4 W.
 Fleck, northwest quarter Sec. 16, T. 2 S., R. 4 W.
 Able, northwest quarter Sec. 20, T. 2 S., R. 4 W.

At Bretzville, Mr. W. Bretz finds coal in the bottom of a branch on the northwest quarter of section 32, one foot thick, having been thinned by erosion at this place. He has also mined coal for shop use on southeast quarter section 30, township 2 south, range 4 west, and has seen out-crops on that quarter section from three to four feet thick. After long trial he reports this as choice blacksmith's fuel. Coal has also been dug to in the well of David Abel, in the northeast quarter of same section.

A ready-made pass-way for the different railroads seeking a northern outlet is furnished by the valley of Hunley's Creek, which traverses the high ridge dividing the waters of the Patoka from those of the Ohio river, and thus offers a level gateway to the engineer through the massive sand

rock. The upper division of the conglomerate here is, but slightly compacted and easily disintegrates. The debris from this washed by the flood waters of the creeks yields a choice article of plasterers' sand. Good beds, which supply the home market, are seen on the Lukens' farm, southwest quarter section 16, township 3 south, range 4. In the same neighborhood is a stratum of clay filled with fragments of quartz and flint, unconformably deposited and probably of glacial or subsequent age.

Ferdinand is a thrifty village, surrounded by a fruitful soil and happy prosperous people. For the latter it is greatly indebted to their Catholic priest, who prudently and kindly cares for the temporal as well as for the spiritual interests of his charge.

Seam K is seen at the top of the hills and knobs, here represented only by a thin stratum of bituminous shale, but with the flinty limestone roof and under-clay well developed. A is found near the water level, under the massive sand rock. The barren seam K is accompanied by other minerals which more than compensate for the absence of the usual carbonaceous deposit.

The "Anderson Valley Mining Company"—J. B. Gohman, Dr. Kempf, Dr. Bindwald, and John Baunline, proprietors—after a thorough examination, opened their mines in the south half section 34, township 3 south, range 4. Here all the different minerals accompanying the place of seam K were found abundant, and are all utilized. Lime is burned from the roof rock; from cavities in the more flinty portions a soft silicious stone is obtained and used for the manufacture of a polishing powder, or "tripoli," of superior quality. The clay, iron stones, and decomposed nodules furnish ochreous paints of seven distinct natural shades. These ochres are free from silex, and after a test of three years by the Louisville and Nashville, the Louisville, Cincinnati and Lexington, the Evansville and Crawfordsville, and the Louisville, New Albany and Chicago railroad companies, and by other large manufacturing establishments, have been found in use profitable, durable, and

satisfactory. By combination of the seven distinct natural colors with white lead, almost any shade may be produced, as may be seen by the fourteen specimen colors deposited in sample jars at the cabinet in the rooms of the State Board of Agriculture.

SECTION AT THE MINES OF THE ANDERSON VALLEY MINING
COMPANY.

Slope	10 ft. 0 in.
Shaly soapstone " <i>steatite</i> " paint.....	3 ft. 0 in.
Dark and light "butternut" paint	1 ft. 4 in.
Dark and light "Bismark brown" paint.	
Bituminous limestone, with <i>Productus punctatus</i> , <i>P. longispinus</i> , <i>P. cora</i> , <i>Spirifer cameratus</i> , <i>S. lineatus</i> , <i>S. Kentuckensis</i> , <i>Nautilus decoratus</i> , <i>Cyrtoceras</i> ———, <i>Terebratula broidens</i> , <i>Athyris subtilita</i> , <i>Hemipronites crassa</i> , <i>Aviculo-pecten providensis</i> , <i>Fusulina cylindrica</i>	3 ft. 0 in.
Limestone, changing into "coral earth," with beautiful plates and spines of <i>Archeocidaris mucronatus</i> , <i>A. Wortheni</i> , Crinoid stems, plates, and arms, stems and crushed plates of <i>Pentremites</i> and other mountain limestone animals.....	0 ft. 8 in.
"Terra de Sienna" and yellow ochre..	1 ft. 1 in.
Coal K.....	.....
Bituminous shale—"dark umber".....	0 ft. 8 in.
"Yellow ochré".....	1 ft. 3 in.
Fire clay with stigmarial rootlets.....	3 ft. 0 in.
Potters' clay—"Dubois cream," or "stone color".....	4 ft. 0 in.
Bedded sandstone and covered to branch.....	75 ft. 0 in.
	103 ft. 0 in.

This locality was selected on account of yielding nearly every kind of mineral needed for the manufacture of these paints, and on account of the remarkable freedom from silica which makes washing unnecessary. The ores are roasted, ground, then graded by screens of different degrees of fineness and the product is ready for market.

Paint stones and ochres are found on almost every hill-top around Ferdinand. The supply is ample to employ an extensive factory continuously, and, to meet the wants of a continent. "Tripoli" found on the farm of Herbert Beike, northeast quarter northwest quarter section 26, township 3 south, range 4 west, is used for making polishing powder. It is a porous mass of silicious material, having the same specific gravity as European tripoli, and is derived from the flinty limestone roof of coal K. This stone was noticed at other points and may be obtained in considerable quantities. Two grades are prepared by the "Anderson Valley Mining Company," one an impalpable powder for polishing gold, silver, and metallic mirrors, another coarser for household and kitchen use. Specimens of the manufactured product were submitted to competent authority for determination. Dr. R. H. Ward, Microscopic editor of the *American Naturalist*, and S. A. Briggs editor of the "Lens," the *Chicago Journal of Microscopy*, after careful examination, report that the earth is not infusorial, and that its actual composition requires further examination.

Good quarry rock is found in the "massive beds," of the conglomerate, specimens of which, long in use, may be seen in the facings and copings of the Catholic church.

A few of the creeks have cut their valleys down to the level of coal A, ninety to one hundred and ten feet below the place of K.

Openings have been made at the following points, with coal from one and a half to two feet thick:

Leuken's, southwest quarter Sec. 13, T. 3 S., R. 4 W.

Ebert, southwest quarter Sec. 11, T. 3 S., R. 4 W.

Hardwick, northwest quarter Sec. 9, T. 3 S., R. 4 W.

Hoffman, southeast quarter Sec. 19, T. 3 S., R. 4 W.

Mehling, southeast quarter Sec. 35, T. 3 S., R. 4 W.

H. B. Kathman's bank has been considerably worked just over the line in Spencer county, northwest quarter northeast quarter section 3, township 4 south, range 4 west. The exposures give the following exhibit:

SECTION AT KATHMAN'S.

Slope.....	.....
Silicious soapstone with plants.....	2 ft. 0 in.
Coal A :	
Inferior coal.....	0 ft. 8 in.
Good bituminous coal.....	1 ft. 2 in.
	————— 1 ft. 10 in.
Fire clay, with <i>stigmara</i> twisted and strangulated into different shapes with balls and tubers separate or connected	4 ft. 0 in.
Bed of creek.....	.....
	————— 7 ft. 10 in.

North of Henrysville, John Fest has opened seam A at several places on northeast quarter section 25, township 3 south, range 5 west, specimens were obtained for analysis. Mr. Fest reports that jack-o'-lantern is often seen of dark nights in the ravine near his coal bank, and would gladly connect the phenomena with hopes of silver ore instead of the true cause—carburetted gases.

The same seam outcrops on the line dividing sections 24 and 25, at the quarter section post, and gives this exposure:

J. FEST AND J. LINGER SECTION.

Slope with flints from roof of K.....	12 ft. 0 in.
Laminated and massive sandstone.....	30 ft. 0 in.
Thin bedded sandstone.....	5 ft. 0 in.

Compact sandstone.....	2 ft. 0 in.
Coal A.....	3 ft. 0 in.
Fire clay, dark.....	4 ft. 0 in.
Branch.....	.....

64 ft. 0 in.

Going west from this point, flints from the limestone roof of K were seen on sections 23 and 22, and a pretty thick bed of clay ironstones ("paintstone") on the Noemiller farm, section 21, all indicating the place of that seam, and forming a good horizon from which to measure down to coal A, which lies about ninety-three feet below.

Sandusky Williams, Esq., reports finding in a well near his residence, section 28, at a depth of seventeen feet, a bed of yellow ochre, three feet nine inches thick, underlaid by a four feet stratum, of ochreous soapstone. Specimens from this fine bed of natural paint were secured for the State Cabinet.

Continuing west, coal K becomes normal. No longer barren, it affords from two to three feet of tolerable coal, and was worked several years since on the Kemp farms, sections 31 and 32, township 3 south, range 5 west.

The limestone roof here loses in a great measure its flinty character, and is often seen in place or in detached blocks from one to three feet thick. At places it is profusely filled with fossils, viz.: *Spirifer cameratus*, *Productus punctatus*, *P. semireticulatus*, *Bryozoans* (3 Sp.), Coral pipes and Crinoid stems.

At Holland, seam K becomes still more persistent, and the accompanying ores of iron are abundant. Good beds of the latter were seen, apparently one and a half to two feet thick, on sections 22 and 23, township 3 south, range 6 west; also on Greenway's farm, northwest quarter section 27, township 3 south, range 6 west, a stratum eighteen inches thick was passed in digging a well, and reported to be of fine quality.

Openings have been made near Holland for local use, viz :

Rosamyer, S. E. qr. S. W. qr. Sec. 14, T. 3 S., R. 6 W.
 Seaba, N. E. qr. N. E. qr. Sec. 15, T. 3 S., R. 6 W.
 Otto, S. E. qr. S. E. qr. Sec. 15, T. 3 S., R. 6 W.
 Schepman, N. W. qr. S. E. qr. Sec. 23, T. 3 S., R. 6 W.
 Feldwich, N. E. qr. S. W. qr. Sec. 23, T. 3 S., R. 6 W.
 Greenway, N. W. quarter Sec. 27, T. 3 S., R. 6 W.
 Licbert, section 24, township 3 south, range 6 west.

At these places the coal was found to range from one to two and a half feet in thickness.

The section taken on the southeast quarter section 29, township 3 south, range 6 west, in Warrick, near southwest corner of Dubois County, shows an additional seam, and the stigmarial under-clay proves conclusively that it is independent.

•SECTION AT INGHAM'S BANK, WARRICK COUNTY.

Slope or covered sandstone.....	50 ft. 0 in.
Thin bedded sandstone.....	10 ft. 0 in.
Silicious shale.....	4 ft. 6 in.
Black sheety slate.....	2 ft. 0 in.
Black sheety slate with pyritous bowlders containing twenty species of fossils, including the gigantic fish <i>Edestus Vora</i>	0 ft. 8 in.
Coal:	
Pure cubic.....	0 ft. 8 in.
Hard splinty.....	0 ft. 8 in.
	1 ft. 4 in.
Stigmarial clay.....	3 ft. 1 in.
Rash coal.....	0 ft. 5 in.
Stigmarial clay.....	1 ft. 4 in.
Dark bituminous clay.....	1 ft. 3 in.
Coal, inferior.....	3 ft. to 2 ft. 0 in.
Fire clay.....	3 ft. 0 in.
	79 ft. 7 in.

North from Holland the ridge of sandstone soon becomes well developed. Rock houses are found under the "Massive" member of the conglomerate on section 34, township 2 south, range 6 west. They have been used as habitations by the Indians, and human bones have been found mixed with alkaline tufa upon the ancient hearthstones, by Dr. Rust, of Holland.

Coal has been worked on the Todrank farm, and from Rother's bank, section 27, township 3 south, range 6 west, large quantities have been hauled to Huntingburg for blacksmiths' use, and found to be of superior quality. Beds of sand similar to those mentioned near Ferdinand, are found on sections 5 and 8, and at Rousher's west half section 4, township 3 south, range 5 west, considerable amounts are gathered and sold for plasterers' use. On the Miessner farm, east half of same section, a deposit of kidney and clay iron stones was noticed, apparently of considerable extent and of excellent quality.

Huntingburg is a thrifty village containing several steam mills, mechanical establishments, and extensive warehouses. Large amounts of tobacco are exported. The soil of the south part of Dubois is composed principally of the reddish brown loam famous for excellent "cigar leaf." The strata accompanying K, here barren, are found at the top of the hill north of the village. The calcareo-magnesian roof, somewhat flinty, is quarried for pavements and foundations. The under-clay develops a thickness of from four to seven feet and is a superior potters' clay. Tested in a smith's forge it burns snowy white without change of form, and invites the attention of manufacturers of queensware and stoneware. Dr. Beeler informs me that it has been examined by experts, who pronounce it superior to any clay in this country, and fully equal to Scottish clay for the manufacture of white crockery. A practical test is needed.

SECTION AT BEELER'S HILL, HUNTINGBURG, (NORTHWEST
QUARTER SECTION 34, TOWNSHIP 2 SOUTH, RANGE 5
WEST.

Soil.....	10 ft. 0 in.
Cherty limestone (magnesian) with sil- icious earths and <i>Productus</i> , <i>Hemi- pronites</i> , <i>Bryozoa</i> , <i>Spirifera</i> , etc.....	8 ft. 0 in.
Soft silicious shales.....	4 to 10 ft. 0 in.
Coal K.....	2 in. to 0 ft. 6 in.
Potters clay, choice.....	5 to 7 ft. 0 in.
Bituminous streak.....	0 ft. 4 in.
Ochre "sienna" color.....	4 in to 0 ft. 6 in.
Dark shale.....	7 ft. 3 in.
Ochreous concretions and iron nodules in soapstone.....	12 ft. 0 in.
Light colored soapstone.....	3 ft. 0 in.
Silicious and aluminous shale contain- ing plant remains and silicified trunks of coal plants two and a half to three feet in diameter.....	20 ft. 0 in.
Shaly and compact sandstones covered.	58 ft. 6 in.
Massive quarry sandstone.....	10 ft. 0 in.
Argillaceous shale.....	4 ft. 0 in.
Coal A :	
Compact lustrous coal.....	1 ft. 6 in.
Block.....	0 ft. 4 in.
	————— 1 ft. 10 in.
Fire clay.....	3 ft. 4 in.
	—————
	136 ft. 3 in.

At John DeBeer's shaft in the eastern part of the village, and at several wells, coal A was found about eighteen feet below the surface, and under strata similar to those given in above section.

About twenty-five years ago, Mr. Geiger bored for water to supply a mill. Tradition of "old settlers" says that at a depth of seventy-five feet he passed through a seam of

coal five feet thick. No out crop of such a seam is visible at other points, hence their report is probably unfounded.

The quarry sandstone at Huntingburg is heavy bedded, with bands one to two feet thick. To the northeast it soon becomes coarse and massive, and half way between this town and Jasper, attains a thickness of seventy feet, and forms a high ridge which is traversed by several creeks following north to the Patoka.

In concluding this report of details, it is proper to remark that the determination of the coal seams, seen at isolated stations and often with but slight exposures of accompanying strata, is given as the best that could be made with the time and opportunities then available. It is believed that they are generally correct, and I find nearly the same determinations adopted by Col. J. W. Foster and other geologists in employ of the different railway companies. With better exposures afforded by the large development hoped for hereafter, the future geologist may correct errors caused by meager material.

ECONOMICAL GEOLOGY.

Dubois county was organized A. D. 1817. The population in the middle and eastern parts is mostly of German descent. The Catholic religion prevails; large churches have been erected by this sect at Jasper, Celestine, St. Anthony, Henrysville and Ferdinand. Moravian Hollanders occupy the neighborhood of Portersville, Huntingburg and Holland. These branches of the German race form communities to some extent isolated from the balance of the State. The German and Dutch languages are generally spoken. Many of the old fashioned customs and habits of the "fatherland" are common. Fete days take the place of ordinary new world festivals. The men are noted for the frugal thrift characteristic of their race, while the women and girls often share the toil of the shop and the field.

The mining development of this county belongs to the future. With plenty of timber for fuel there has been no

demand for coal, except the small amount needed for smith's use. When part or all of the different railways now projected shall have been finished, means of outlet for the product will cause new mines to be opened; mechanical and manufacturing establishments and the spirit of progress will infuse new vigor into every artery of life.

The coal deposits of Dubois county, although thinner than those of more favored districts, will be found ample to supply all home demand for mills, glass works, potteries, etc., etc., and at the same time afford a generous allowance for export.

Extensive beds of iron ore occur in connection with the subcarboniferous sandstone. Highly silicious, they will be found most valuable to mix with the purer ores of Missouri and Michigan. Very considerable deposits of kidney ore as seen in the western and southern parts of the county, some of which will justify exploration. It is not probable, hardly possible, that the ores of any of the other useful metals will ever be found in quantities.

CLAY.

Material for the manufacture of bricks is abundant in all parts of the county. The under-clays accompanying seam A are generally silicious, and will prove suitable for the manufacture of fire brick. The under clay of seam K is usually plastic, and at some points in the southern part of the county seems to afford choice material for potters' use. A practical test, will, it is believd, develop qualities in the Huntingburg clay which will command the attention of manufacturers.

PAINTS.

The paint mill of the "Anderson Valley Mining Company" is located at the town of Ferdinand. The roasting furnaces, mill and stamps have a capacity for grinding and preparing 2,500 pounds a day. The supply of mineral at their mine and surrounding openings is unlimited. The quality of their paints is eminently satisfactory and chal-

lenges comparison with the best foreign competitor. The only want is cheap transportation which will soon be supplied by railroads now in process of construction.

STONE.

The "subcarboniferous" or "conglomerate" sand rock of this county is well developed, and will yield an unlimited amount of stone suitable for superstructures as well as foundations. Fresh from the quarry it is soft enough to work readily, but hardens on exposure. Noted for a capacity to resist the action of fire, it merits and will command the attention of city architects and the erectors of furnaces and forges.

TIMBER.

The forests are filled with the following varieties, viz.: White, black, chestnut and over-cup oak, yellow and white poplar, walnut, beech, sugar, elm, gum, and a large number of small trees. Mistletoe is found growing on elms and the black gum. Large rafts of poplar logs are floated down Patoka river.

SOIL.

The soil of the county is not of the best. Fair crops of corn, wheat, oats, and grass are produced. Underdraining, with a modern system of culture, will develop a high value for the flat bottoms near and along the Patoka. The southern part of the county is well adapted to the production of a superior quality of tobacco. Extensive warehouses for storing this product are erected at Huntingburg, Holland, and Ferdinand, and large amounts are exported.

FRUITS.

The climate and soil is well suited for the culture of the tender fruits. Here the pear and the peach is free from many disasters and diseases incident to a more northern situation. The quality of the fruit is excellent, and we hope that the people of this county may be induced to reap and enjoy the same luxuries and the same profits that accrue to citizens of counties east and west of them.

Acknowledgments are due to the following gentlemen for information and assistance, viz.: Col. B. B. Edmonston, Dr. Wellman, Dr. Stevenson, C. Doane, and the county officers at Jasper; Dr. Freeland, at Portersville; Hon. Leroy Cave, at Ludlow; Wm. King, at Birdseye; Dr. Kempf, John B. Gohman, and the Abbot of St. Meinrad, near Ferdinand; Dr. Rust and S. Williams, at Holland, and Mr. Rothert and Dr. Beeler, at Huntingburg.

Thanks are returned to the President and Directors of Jeffersonville and Indianapolis, and Evansville and Crawfordsville Railroads, for favors rendered with their usual courtesy.

GEOLOGY

OF

PIKE COUNTY, INDIANA.

GENERAL FEATURES.

Pike County is bounded on the north by Knox and Daviess, east by Dubois, south by Warrick and Gibson, and west by Gibson; and contains 338 square miles. White river forms its northern limit. Patoka river crosses it centrally from east to west. The former is navigated at the spring and winter floods by steamboats and broad-horns, and the latter by rafts and flatboats. Numerous creeks and branches in all parts drain off the rain fall. The surface is level or gently undulating, except the middle portion of the eastern side, where hills and deep, stone-walled valleys are contrasted with romantic boldness. The bottoms and terraces of White river are extensive and wonderfully productive. Those of the Patoka and its affluents are of exaggerated width compared with the present sizes of these streams, and, generally formed from "modified loess," are cold, impervious to air and moisture, and not well improved. Springs of pure water are scarce, and owing to the constitution of the soil, many wells in the eastern part of the

county can not favorably compete with cistern water for drinking and culinary purposes.

The upland soil is a black, brown, or red loam, and was originally covered with a magnificent growth of timber. Some unrivalled groves of white oak, poplar, and hickory are still standing.

The beds of coal are numerous, of great thickness, and of good quality.

These treasures of the field, the forest, and the mine, are isolated and undeveloped. They urgently invite the construction of railways for their transportation, and promise immediate and remunerative returns.

SURFACE GEOLOGY.

The Glacial Drift, so constant a feature in the central and northern parts of the State, can hardly be recognized in this county. Beds of pipe and potters' clay, on Case's farm, near Highbanks, obscurely laminated and interchanging with layers of sand, are with doubt referred to this age. True bowlders and gravel from the drift are sparingly met with, even at the southern boundary of the county; but so rare are they as to be pointed out as curiosities. Their transportation has been effected by rivers and water courses.

The Loess Loam is found in place on a few of the high hills northeast, south and southeast from Pikesville. Modified and washed by the rains of ages, the ash-gray impalpable sands of this deposit, cover the hill sides, and form the cold soils of the Patoka bottoms.

At the close of the loess epoch, the great currentless rivers and lakes, on whose borders this loamy soil was deposited, were, by oscillation in the earth's crust, drained away by more rapid discharge of their waters to the southwest. The change was probably gradual and was accomplished in the course of many centuries. During this time the Wabash, White and Patoka rivers, and perhaps the Ohio, traversed the western and southwestern parts of the county, and taken separately or as a whole, have left marks by which

their courses may be indistinctly traced. The valley of South Patoka, a basin nearly eight miles square, has been eroded to a depth of from 120 to 160 feet, but still retains a surrounding wall of peaks and hills. In this wall of hills the strata are in regular order. One is the counterpart of the others; showing conclusively that the basin owes its origin to erosion. From the absence of clays and gravels, this was done subsequent to the glacial period, and as I infer, by the joint action of two or more of these rivers.

The results indicated above, and other facts noticed in the detailed report, warrant the opinion that rivers have traversed the western and southwestern parts of this county in almost every direction. This view is further confirmed, by the existence of a large system of terrace deposits southwest from Winslow, locally known as the "Barrens," which is evidently an old river-bed silted up with fluvial drift, and the "mulatto loam" or "poplar divide" running parallel with and between Patoka and White rivers.

To the east of Petersburg, on the Jasper road, is spread out a large extent of country almost perfectly level, having a black rich soil, and a young growth of timber. This was evidently a prairie country at no distant period. Beneath the surface, beds of clay and sand, distinctly laminated, with fragments of trees and enormous grape vines, point out the lacustrine origin of the plain, and indicate a warm climate for the growth of the vegetation inclosed.

This plateau is bounded at the north by ancient sand bars on the bluffs of White river, one hundred to one hundred and ten feet above the present channel, which indicate the high-water level of the ancient river. These are further noticed in the Geology of Dubois county, and conspicuous examples may be seen at Sand Hill north of Petersburg, at Highbanks, and at the railroad cut in the north part of township number 1 north, range 7.

PALEOZOIC GEOLOGY.

The only rocks visible in this county are the massive conglomerates or subcarboniferous sandstones, and those of the

coal measures proper. The following connected section brings in one general view all the rocks and coals from the uppermost seam of the Indiana and Illinois coal fields down to the conglomerate seam A. It will be seen that the space from A to K, so richly filled with block coals in Clay county, is here almost entirely barren. A single seam in the southwest part of the county, apparently located between A and K, may, with doubt, be referred to I. The section commences near the county line, west of Centerville, and ends at the lowest visible beds east of Pikesville.

CONNECTED SECTION.

SPACE.		FT.	IN.	
		1—40		lenses.
84.		2—10		Drift.
		6—8		Lacustrine clay.
		8—20		Micaceous and ferruginous sandstone. "Merom Rock."
		3—6		Argillaceous limestone.
1.6		0—1	6	Rash COAL and slate.
		2—4		Fire clay.
28.		15—20		Siliceous shales and flagstones.
		5—4		Limestone, sometimes argillaceous.
.8		0—0	8	Rash COAL and slate.
		2	4	Buff-colored fire clay.
		8—25		Siliceous shales and thin bedded sandstone.
42.4		40—15		Quarry sandstone, buff.
		30—2		Siliceous shales. (ings.
		12—5		Clay shales with carbonaceous part-
		3—0		Black slate.
4.4		1—4	4	COAL N.
		4—2		Fire clay.
		20—12		Siliceous flagstones.

CONNECTED SECTION—Continued.

SPACE.		Fr.	In.	
18.6		2 — 3		Ferruginous limestone.
		3 — 1		Calcareous and clay shale.
		0 — 0	6	Black slate.
2.6		0 — 2	6	COAL M.
		1 — 2	8	Fire clay.
		18—21		Argillaceous sandstone.
62.8		20		Siliceous shales and flagstones.
		5 — 14		Clay shale.
		10— 6		Soapstone with fossil plants.
10.9		3 — 10	9	COAL L.
		5		Fire clay.
		3		Soapstone.
		12—20		Soapstone and clay shale.
		12		Thin bedded sandstone.
72.		10		Siliceous flagstones and sandstone.
		5 — 9		Aluminous shale.
		2 — 4		Clay shale with iron nodules.
		2 — 3		Calcareo-magnesian limestone.
		2 — 3		Aluminous shale and ochre.
		2 — 3		Black bituminous sheety slate.
		1 — 0		Pyritous clod.
5.9		5	9	COAL K, from 2 to 10 ft. thick.
		5		Fire clay.

CONNECTED SECTION—Continued.

SPACE.		FT.	IN.	
79.3		20		Coarse, ferruginous laminated sand-rock.
		70—40		Massive conglomerate.
		5 —10		Gray aluminous shale.
		0 — 2		Calcareous shale.
		1 — 2	3	Black slate and cannel coal.
1.6		5 — 1	6	COAL A.
9.4		3	4	Fire clay.
		6		Siliceous shales and flagstones.
430.	Total.			

RECAPITULATION

SPACE.		Ft.	In.	
		54		Space.
		1	8	Rash COAL.
		28		Space.
			8	Rash COAL.
		49	4	Space.
		4	4	COAL N.
		18	6	Space.
		2	6	COAL M.
		62	8	Space.
		10	9	COAL L.
		72		Space.
		5	9	COAL K.
		79	3	Space.
		1	8	COAL A.
		9	4	Space.
	Total.	430	1	

The foregoing section and recapitulation give a general view of the rocks of Pike county, and represent the number and relative position of the coal seams as nearly as may be determined in their present undeveloped condition.

Coal A underlies the whole county, but outcrops only in ravines amongst the hills on each side of Patoka river, near the eastern border. Varying from one to four feet seven inches in thickness, it usually contains at least one stratum of about fourteen inches of good, compact, splinty cannel or block coal. Hard, free from dust, and rich in carbon, this stratum is suitable alike for parlor use or that of the blast furnace. When thickened to a much greater extent, it has been done at the expense of its more valuable qualities, and becomes impure and pyritous. This seam is often topped with a layer of pure, choice cannel coal from four to ten inches in thickness, and occasionally the black bituminous roof slate is replaced by a fair article of cannel coal, rich in gas. In such last mentioned banks, at the junction of the slate and cannel, are found casts of the horny-shelled *Lingula*, *Chonetes* and *Piscina* in good preservation; also faint impressions of *Productus Spirifer*, etc.; the thick calcareous material of the latter made soluble and wasted during the process of fermentation which occurred in the vegetable matter with which they were in contact prior to the change which formed coal.

The calcareous shales are pretty persistent, and are sometimes hardened into dark bituminous limestone, containing *Spirifer cameratus*, *S. lineatus*, *Productus punctatus*, *Nautilus decoratus*, *Orthoceras Rushensis*, fishbones and Crinoid stems.

The gray aluminous shales are highly charged with pyrite, (sulphuret of iron,) which, on exposure to the air, decomposes. This renders the whole stratum soft and friable, which, torn out by winter torrents, leaves spaces, roofed by the overlying sandstones, known as "rock houses."

The coarse ferruginous sand rock below coal K, is readily identified as the massive conglomerate. Although no pebbles are here present, it offers all the other character-

istic features of that group. It may be quarried in immense blocks. The quantity is unlimited. Endowed with a capacity to resist in a very great degree the action of heat and the variations of the atmosphere, this rock will be found a material of great value for the hammered masonry of foundations, piers, etc. By careful selection, stone of several different tints may be obtained, which will contrast with good effect in chiseled work. The upper member of this deposit is soft, coarse, and liable to disintegrate. The geological level of the silicious ores, so notable in counties to the north and east, is here but slightly charged with ores of iron. These rocks are a continuation of the conglomerate ridge which traverses Dubois county from east to west, south of the Patoka, and at its most westerly terminus passes beneath the surface a short distance northwest of Winslow.

Coal K is found high up on the sides of the hills and peaks which abound in the region of the conglomerate sandstone. Rapidly dipping to the north, south, and west, it as rapidly increases in thickness until, near the line dividing ranges seven and eight, it attains a generous width, ranging from five feet to nine feet seven inches at Dr. Posey's bank, section 15, township 1 north, range 8 west. To the east, this coal is somewhat splinty, but generally it is a fat, caking coal, rich in volatile matter, and on combustion leaves a red ash with some clinker, indicating the presence of sulphuret. On trial it has been found to be an excellent grate and steam coal, and is highly esteemed by blacksmiths. A stratum of black, sheety slate, from three to three and a half feet in thickness, overlies K, and forms an excellent roof. In the lower member of this slate are a great many large pyritous bowlders or "pot-stones," some of large size and filled with marine fossils.

Still above this, and even more persistently accompanying K, is a band of limestone from two to three and a half feet thick. At the eastern side of the county it is tolerably pure and has been burned, furnishing a strong dark colored sample of lime. It contains the following fossils, viz.:

Productus punctatus, *P. semireticulatus*, *P. costatus*, *Spirifer eameratus*, *S. lineatus*, *Athyris subtilita*, *Pinnæ*, *Myalina*, *Allorisma*, *Discina* (large n. s.), *Nautilus decoratus*, *N.* (n. s.), and Crinoid stems. At Dr. Posey's bank and northeast from Pleasantville, this rock becomes sandy and at the same time highly magnesian, and in addition to the above list of fossils, contains *Gasteropods*, *Aviculopecten Providensis*, a *Phillipsia*, and *Chonetes mesoloba* in abundance.

The silicious flagstones and quarry sand rock is sometimes used for foundations and hammered masonry. Not of the best, it is only adopted when choice stone is not attainable.

Seam L is found capping the tops of the highest hills near Pikesville, and near the surface in the highlands east of Otwell, one and a half to two feet thick. From north to south through the center of the county, this seam has been almost wholly eroded. At Hathaway's, and Well's and Whitman's banks, one mile southwest of Winslow, it is seen again, and thence may be found with few interruptions to the western border, ranging in thickness from four to ten and a half feet. Throughout its whole extent, L is a gray or white ash caking coal, burning well in grates and steam furnaces, and will be found a choice fuel for locomotive and rolling mill use. L, as usual, is generally overlaid by clay shales and a thin bed of soapstone known as the "fern bed," containing many plant remains amongst which were noticed the following characteristic species: *Pecopteris arborescens*, *Neuropteris rarinervis*, *Annularia longifolia*, *Sphenophyllum Schlotheimii*, *Asterophyllites equisetiformis*, *Cordaitea angustifolia*, *Paleoxylon*, *Lepidodendron elegans* and *Sigillaria reniformis*. A few points excepted, these shales are continued up to the next seam, and, although sometimes silicious and so compact as to seem to the quarryman enduring rock, yet on account of their aluminous nature they will on exposure to the elements soften and decompose.

Outcrops of seams M and N are found in the region about three miles west of the line dividing ranges 7 and 8, except in the southwestern part of the county where both are eroded. Soon after their first appearance, these

seams in the northern townships dip at the rate of from thirty to fifty feet per mile in a northwesterly direction; but to the west and southwest, in the same course, beyond Pleasantville, M is an inconstant, sulphurous seam and of little or no practical value. It is accompanied by an overlying bed of calcareous shale inclosing carbonates and sulphurets of iron. Above this is a ferruginous limestone of great persistence, from two to three feet thick, and containing a few indistinct Gasteropods, *Spirifer lineatus*, and *Chaetetes milleporaceus*, in thick layers. Generally this bed is highly ferruginous and will pay for transportation to iron furnaces as a rich flux.

Seam N is worked at two localities near Petersburg; at both of which places it is found in isolated knolls of no great extent. Hence, by exposure to air and moisture, it has been robbed of some of its gaseous properties. The coal is free from sulphur, burns with a clear flame, and leaves a white ash without clinker. In the western part of the county, where covered by heavy hills, it contains more volatile matter, and will furnish fair to good gas coal. Above N, occurs a bed of buff or yellow sand rock, of considerable persistence. It has been quarried near Centerville and Hawthorn, and will furnish large amounts of good stone.

The *rash coals* are not constant. They were not seen of workable thickness in this county; but the underclays and overlying limestones are of great persistence, and when by erosion of intermediate strata, as at "Snake Knob," in Warrick county, the two limestones are brought close together, they form a marked feature, capping the hills with a hard argillaceous clinking limestone, that has proven a bulwark against the currents of erosive rivers and the levelling power of the elements. These seams are believed to be the highest coals in the Indiana and Illinois coal fields.

Still above is found a bed of coarse, soft red sandstone, probably equivalent to the "Merom rock" in the geology of Sullivan county. (Ind. Report 1871.) For the present

it is included among the rocks of the coal measures, but facts not yet fully studied will, it is believed, assign this rock to a higher position and a later age.

The foregoing is a general outline; to this will now be added representative sections and details for local information.

LOCAL DETAILS.

The conglomerate spur which pierces the coal measures from the eastern side of the county terminates with abruptness. The strata dip rapidly and thus a line of precipitous bluffs formed a mural breakwater, upon and against the slopes of which the different coal seams were successively deposited.

Commencing at the highest known rocks, the following section, taken in section 7, township 1, range 9 west, Gibson county, at a point 235 feet above the Wabash, is given as a better showing of the upper strata than any seen in this county :

SECTION IN GIBSON COUNTY.

Loess and river sand.....	20 ft. 0 in.
Pebbly, fluvial drift	8 ft. 0 in.
Soft white and yellow sandstone.....	30 ft. 0 in.
Soft laminated sandstone.....	22 ft. 0 in.
Quarry sandstone, "Merom rock".....	18 ft. 0 in.
Calcareous and argillaceous shales, and lime rock.....	10 to 3 ft. 0 in.
Black bituminous slate	1 ft. 4 in.
<i>Rash coal</i>	8 in. 0 ft. 2 in.
Fire clay.....	2 ft. 6 in.
Clay shales.....	6 to 15 ft. 0 in.
Limestone, with Crinoid stems	2 to 4 ft. 0 in.
Clay shale.....	2 to 5 ft. 0 in.
Black slate.....	3 to 1 ft. 0 in.
<i>Rash coal</i> (reported).....	2 ft. 0 in.
	134 ft. 0 in.

This section is interesting from the fact that the coarse, loose sandstone near the top may be traced almost continuously to the Wabash river in the vicinity of Hazleton. This shows the abruptness of the local dip in that direction and the great depth at which the lower coals must there be sought.

West of Centerville is a long ridge, which, at a height of 135 feet above Patoka, is covered with an ancient river sand-bar. This constitutes a warm loamy soil. Elevated above the region of sudden changes of temperature, it is to a great degree exempt from late frosts and invites the attention of fruit growers. The tender fruits are grown successfully. Pears ripen in perfection; and at the time of my visit the trees were breaking down with large, sweet red peaches. From the top of this hill, near Olive Branch Church, can be seen the spires at Oakland city, seven miles to the south, and other points ten miles away down and across Patoka valley.

That part of the connected section, from the rash coal down to coal N, gives an exhibit of the rocks in this neighborhood. A local section of coal N, the only seam here worked will be added.

SECTION AT FALL'S BANK.

Heavy bedded sandstone.....	10 to 20 ft. 0 in.
Calcareous and argillaceous clod.	14 to 0 ft. 7 in.
Coal N:	
Slaty coal.....	2 ft. 4 in.
Pyritous partings.	3 in. to 1 in.
Choice caking coal	1 ft. 1 in.
Slaty pyritous coal	0 ft. 4 in.
	3 ft. 10 in.
Fire clay to water.....	3 ft. 0 in.
	27 ft. 5 in.

The upper division of this coal burns without clinker, and leaves a white ash. It is too splinty for blacksmiths' use. Outcrops or openings with an average thickness of three and a half feet were seen on the following lands, viz.:

Lewis Wilson, northwest quarter Sec. 13, T. 1 S., R. 9 W.
 Lewis Wilson, southwest quarter Sec. 13, T. 1 S., R. 9 W.
 R. Falls, N. W. qr. N. E. qr. Sec. 24, T. 1 S., R. 9 W.
 W. Carr, N. E. qr. N. E. qr. Sec. 24, T. 1 S., R. 9 W.
 Mr. Hellsby, south half Sec. 19, T. 1 S., R. 9 W.

Going east, the ferruginous limestone (iron ore) covering coal M, and sometimes the coal itself, may be seen almost connectedly from Dongola to the north side of township number 1, south, range 8 west. Large quantities have been thrown out in digging the canal north of Hosmer. This would be valuable as a flux for iron furnaces, enriched, as it is, with a very appreciable amount of iron. Thin outcrops of M are seen near and in the canal bed on sections 10, 22 and 27, township 1 south, range 8 west; none reported to be of workable thickness. Tradition, which could not be traced to a reliable source, reports coal L five feet thick in a sixty feet bore, near the base of "Slickum hill." This is the average space between L and M from neighboring localities, and to say the least, is probably correct.

On the road leading from Hosmer to Petersburg, seam N is worked on Hosea Alexander's land by H. Smith. The coal comes out in good sized blocks, has a glossy metallic lustre, burns with much flame and leaves a white ash with no clinker. Considerable quantities have been mined to supply mills and factories at Petersburg.

SECTION AT HOSEA ALEXANDER'S.

Silicious shale.....	6 ft. 0 in.
Compact soapstone.....	1 ft. 6 in.
Gray soapstone, "fern bed," with <i>Pecopteris arborescens</i> , <i>Neuropteris rarinervis</i> , <i>N. hirsuta</i> , <i>Sphenophyllum Schlotheimii</i> , <i>Asterophyllites longifolium</i> , <i>Calamites</i> , <i>Cordaites borassifolium</i> , <i>C. angustifolium</i> , <i>Lepidodendron</i> , (—————), <i>Sigillaria</i> and <i>Stigmaria</i> , abundant	2 in to 0 ft. 11 in.

Coal N :

Laminated coal.....	0 ft. 6 in.
Compact good coal.....	2 ft. 0 in.
Parting blk. sulph..	3 in. to 0 ft. 1 in.
Choice coal.....	2 ft. 0 in.
	————— 4 ft. 7 in.
Fire clay, plastic.....	5 ft. 6 in.
Fire clay with nodules and pebbles.....	1 ft. 2 in.
	—————
	19 ft. 8 in.

Outcrops of same were noticed on the adjoining lands, section 34, township 1 north, range 8 west, and section 4, township 1 south, range 8 west. More will be discovered in the adjacent knolls, but as this seam has suffered much from erosion the patches will be isolated and of no great extent.

Petersburg is pleasantly situated in the fertile valley of Prides creek, two miles south of White river. During the short life of the Wabash and Erie canal, it was the center of a large trade in dry goods, agricultural products, and coal. Since the canal was abandoned, the citizens have been compelled to look out for other means of transportation. High hopes are entertained of securing one of the proposed lines of railway, and thus surpass their former prosperity. Good crops of corn, wheat, oats, and grass are raised. Fruit is abundant and of superior quality. A few miles to the south, is an extensive grove of giant oaks and poplars. All offer paying inducements for railway construction.

In mineral wealth the neighborhood is still richer. At Sand Hill, two miles north of town, the following section was taken, where the ferruginous limestone overlying seam M may be seen dipping west toward "Rocky Ford" at the rate of sixty feet to the mile. It is probable that the dip is still greater in a direction a little north of west.

SECTION AT SAND HILL.

Ancient river sand.	10 to 20 ft. 0 in.
Silicious shale.....	7 ft. 0 in.
Soapstone with <i>Pecopteris</i> , <i>Neuop-</i> <i>teris</i> , <i>Asterophyllites</i> , <i>Cordailes</i> , and <i>Flabellaria</i>	0 ft. 6 in.
Coal N.....	3 to 4 ft. 4 in.
Fire clay.....	2 to 4 ft. 0 in.
Soapstone.....	8 ft. 0 in.
Silicious shale.....	2 to 12 ft. 0 in.
Ferruginous limestone, with <i>Pro-</i> <i>ductus punctatus</i> , <i>Spirifer line-</i> <i>atus</i> , <i>Cyathaxonia prolifera</i> , <i>Chæ-</i> <i>tetes milleporaceus</i> , <i>Athyris subti-</i> <i>lita</i> , and <i>Gasteropods</i>	2 ft. 4 in.
Calcareous and pyritous clay.....	3 to 1 ft. 0 in.
Coal M :	
Slate and coal.....	0 ft. 6 in.
Pyritous and bitumin-	
ous clay.....	0 ft. 8 in.
Caking coal.....	1 ft. 8 in.
	2 ft. 10 in.
Fire clay.....	8 ft. 0 in.
Sandstone	5 to 20 ft. 0 in.
Covered silicious flags and shales...	20 ft. 0 in.
(Low water in White river.)	
Soapstone.....	10 ft. 0 in.
Coal L (reported).....	8 ft. 0 in.
	127 ft. 4 in.

The strong dip mentioned before would, in reverse, carry all these coals above the surface at Petersburg; and hence we find they have all been eroded with a possible exception of L at a few isolated points. Borings for water at several wells in town have, according to report, found coal, or a

black slate filled with boulders similar to the roof-rock overlying coal K. A shaft and bore near the woolen mill in the southwest part of town, is reported to have found coal K ten feet thick, with the following exhibit:

SECTION IN PETERSBURG.

Soil and clay.....	28 ft. 0 in.
Shelly stone.....	10 ft. 0 in.
Slate and boulders.....	2 ft. 0 in.
Coal K.....	10 ft. 0 in.
Fire clay to bottom.....	2 ft. 0 in.
	52 ft. 0 in.

Going northeast on the Washington road, we ascend to the elevated ridge bordering White river. Near the summit, about one hundred and thirty feet above low water, coal L one and a half feet thick was found in digging wells on the lands of J. Vaughn and S. Mafflety, not more than eighteen to twenty feet under the surface, with seam K thirty to fifty feet below in ravines. The strata probably dip from this place in every direction, as may be learned from disconnected exposures. A deep bore would definitely settle some doubtful points.

Two miles north of Petersburg, on Lick and Muddy creeks, and between them, coal K is magnificently developed—A crowning effort of the carboniferous age. The solid coal ranges from five and a half to over nine feet on Dr. Posey's land, section 12, township 1 north, range 8 west. A man six feet high can generally walk erect in Posey or Shandy's mines and have considerable space overhead. The seam furnishes a rich, gaseous, caking coal, which burns with much flame and leaves a red ash with some clinker. It is a good coal for steam or grate use, and is sought after and hauled long distances by blacksmiths. The following section, taken at Dr. Posey's mine, section 13, township 1 north, range 8 west, gives a general view of the neighboring exposures, except that the overlying limestone is purer and

thinner in some localities, and at others highly ferruginous and compact; at Shandy's bank the seam is not so distinctly laminated, and the coal is more homogeneous:

SECTION AT DR. POSEY'S MINE.

Sandstone.....	5 to 20 ft. 0 in.
Magnesian, limestone with <i>Productus punctatus</i> , <i>P. semireticulatus</i> , <i>P. costatus</i> , <i>Discina</i> (n. s.) <i>Spirifer cameratus</i> , <i>S. lineatus</i> , <i>Allorisma</i> , <i>Astartella</i> , <i>Nautilus</i> <i>decoratus</i> , <i>Aviculo-pecten</i> <i>Providensis</i> , <i>Lingula</i> , and Crinoid stems.....	4 ft. 0 in.
Ferruginous limestone.....	3 to 1 ft. 4 in.
Dark pyritous argillite filled with <i>Productus</i> , <i>Chonetes</i> , <i>Cephalopods</i> , and <i>Gasteropods</i> , in con- fused pockets.....	2 to 0 ft. 0 in.
Black sheety slate with pyritous ironstone boulders from one to five feet in diameter.....	5 ft. 0 in.
Coal K: Thin bedded, often cannel	0 ft. 6 in.
Steam coal.....	1 ft. 10 in.
Parting of black sulphur.....	0 ft. 1 in.
Good steam coal.....	2 ft. 4 in.
Parting (pyritous).....	0 ft. 2 in.
Smiths' coal.....	1½ to 2 ft. 4 in.
Grate coal (pyritous).....	1 ft. 0 in.
	8 ft. 3 in.
Stigmarial fire clay.....	5 ft. 5 in.
	44 ft. 0 in.

The great iron boulders or "pot stones" fall down from the roof, after exposure, and hundreds of tons could be
G. R.—17

obtained here. I suggest to iron makers the feasibility of separating the sulphur on the spot by roasting with refuse coal, and in this way secure a large quantity of iron at little cost. Decomposition of the pyritous and aluminous shales produce quantities of alum and copperas in Dr. Posey's mine. At an early day copperas was here manufactured for home use, one gallon of water leached from the mine yielded one pound of that salt.

In the older part of this mine, long ago exhausted, owls and great flocks of bats have taken up their quarters. Back in the ghastly twilight one will be surprised to find that the old timbers and props have seemingly come to life again. They have sent out strange twisted and forked branches, some white, others gray or dusky, and all decked with globules of condensed water, which sparkle like diamonds. Some of these fungi were two feet long and presented a never ending medley of grotesque unsymmetrical forms. The timbers were often coated with patches of a leathery white substance, which probably at a time of greater darkness would blaze with phosphorescent light (fox-fire).

Coal K has been worked or opened in this vicinity as follows, viz.:

- Dr. Posey, 4 drifts, Sec's 12 and 13 T. 1 N., R. 8 W.
- Shandy, shaft and slope, Sec. 13, T. 1 N., R. 8 W.
- Holloway, drift, Sec. 18, T. 1 N., R. 7 W.
- Bennett, drift, Sec. 7, T. 1 N., R. 7 W.
- Adams, drift, Sec. 7, T. 1 N., R. 7 W.
- Hawthorn, drift, Sec. 7, T. 1 N., R. 7 W.
- Hawthorn, shaft to L (?), Sec. 7, T. 1 N., R. 7 W.
- DeBruker, northwest quarter Sec. 8, T. 1 N., R. 7 W.
- Case, (reported), Sec. 20, T. 1 N., R. 7 W.

Dr. Posey's bank has been worked over twenty-five years. About four acres have been exhausted supplying the demand of local market and smith-shops for a region twenty miles around, and for shipment by canal and river to Evansville, Mount Carmel, Graysville and New Harmony. The

proprietor estimates that over one million bushels have been sold.

From the Posey and Shandy mines, southeast quarter section 13 township 1 north, range 8 west, coal K dips rapidly to the northwest. Near the river flats, a test shaft was put down to the coal at a considerable depth below the surface. Along the canal and bank of the river, in northwest corner of section thirteen, is a band of ferruginous limestone, with *Chaetetes milleporaceus*, exactly similar to the bed overlying M at all other points. A seam of coal similar to the general aspect of M is present, while below in the river, with the usual space (sixty-two feet) intervening, is a coal, according to descriptions furnished me, exactly analogous with L. This requires a sudden and rapid dip of strata to the northwest, of not less than one hundred feet to the mile. A dip of such intensity is barely possible. Hence more exact data are necessary before positive determinations can be made.

At DeBruler's bank, northwest quarter section 8, township 1 north, range 7 west, the roof slates afford a variety of fossils, viz.: *Productus*, *Chonetes*, *Discina*, *Bellerophon*, *Macrocheilus* and *Pleurotomaria*, some represented by several species.

SECTION OF DE BRULER'S COAL.

Fat cancell-like coal.....	0 ft. 4 in.
Steam coal.....	3 ft. 0 in.
Sulphur parting.....	.....
Good bituminous coal.....	1 ft. 5 in.
Parting.....	.....
Choice bituminous coal.....	1 ft. 0 in.
Rash coal.....	1 ft. 8 in.
7 ft. 5 in.	

Rhoads & Hawthorn's bank, on the west half northwest quarter section 7, township 1 north, range 7 west, was once worked extensively and the product shipped by canal.

The seam averages 5 feet, and is a good sample of caking coal. At one time the canal broke opposite this bank, and exposed beneath its bed a ledge of coal reported to have been six or seven feet thick, fifteen feet below the upper seam. Whether a lower seam or a fallen ledge of K, there was no evidence to determine.

Ascending White river, we find, on section 4, township 1, north, range 7 west, an ancient sand-bar, high up on the river bluffs, cut through by the "Straight Line Railroad," showing a thickness of twenty-four feet. In section 10, on lands of C. White, the same company quarried an amount of stone sufficient for the high piers necessary to bridge the river. This material has been lying here exposed to frost and air for a period of sixteen years. It weathers well. The bed of sandstone quarried here, at McCain's, Postlewait's, and Crowe's, is compact, splits readily, and chisels well. Generally the material overlying coal L is too argillaceous to be valuable for building purposes. This is exceptional, and was evidently compacted by currents of water powerful enough to transport the coarse sands of which it is composed. As is usual in such cases, we find the underlying coal thin and partially eroded by said currents.

Coal has been worked to a very considerable extent on John Crowe's farm, section 10, township 1 north, range 7 west. Quantities have been exported by flat-boats on the river. It is a choice caking coal, burns with white flame, runs together but little, and leaves a white ash without clinker. It is so free from sulphur that a quantity which had been exposed to the weather "in stock" for six months, showed no efflorescence of copperas.

SECTION AT CROWE'S.

Slope.....	.....
Sandstone, soft and coarse.....	11 ft. 0 in.
Sandstone, thin bedded.....	12 ft. 0 in.
Clay shale and soapstone.....	9 ft. 0 in.
Coal L?	3 ft. 6 in.

Fire clay.....	3 ft. 9 in.
Covered.....	50 ft. 0 in.
Hard sandstone	1 ft. 6 in.
Soapstone, with iron nodules contain- ing zinc blende.....	5 ft. 0 in.
Flagstones and ferruginous limestone..	12 ft. 0 in.
Coal K ? in White river.....	? ft. ? in.
107 ft. 2 in.	

Continuing up the river, we find bluffs capped with fluviatile sands one hundred to one hundred and thirty feet above the channel. On G. W. Daily's land, southwest quarter, northeast quarter section 13, township 1 north, range 7 west, is the following outcrop :

SECTION ON DAILY'S FARM, Highbanks.

White fluviatile sand with shells.....	33 ft. 0 in.
Red clay, modified drift.....	8 ft. 0 in.
Blue potters' clay—glacial drift ? with trunks of trees and vines.....	10 ft. 0 in.
Soft disintegrating sandstone.....	11 ft. 0 in.
Coal, rash.....	0 ft. 5 in.
Clay parting.....	0 ft. 1 in.
Coal, good.....	1 ft. 6 in.
Coal, rash.....	0 ft. 2 in.
Stigmarial clay.....	2 ft. 2 in.
	5 ft. 0 in.
69 ft. 2 in.	

Coal in this vicinity outcrops, or has been worked as follows, viz.:

Thomas Crowe's, north half section 10, T. 1 N., R. 7. W.
 Clint White, N. W. qr. S. E. qr. Sec. 10, T. 1 N., R. 7 W.
 McCanes, northwest quarter Sec. 24, T. 1 N., R. 7 W.
 G. W. Daily, northeast quarter Sec. 13, T. 1 N., R. 7. W.
 J. Hancock's, S. half N. W. qr. Sec. 18, T. 1 N., R. 6 W.

J. Mitchell, S. E. qr. S. E. qr. Sec. 7, T. 1 N., R. 6 W.

Gray, north east quarter Sec. 19, T. 1 N., R. 6 W.

T. Case, northwest quarter Sec. 19. T. 1 N., R. 6 W.

South of Highbanks, on the way to Otwell, in section number 30, where the road crosses a branch flowing into Rocky run, numerous sink holes or conical pits were noticed. The branch had cut down to a stratum of impalpable quicksand. Here, in past time, herds of buffalo would gather to wallow in the fine sand and dust, as their descendants still do in the dust "wallows" of western Kansas. Well worn trails or paths of an ancient date, were noticed leading to this favorite resort.

Otwell is a vigorous young town. It is situated in the center of a level tract of land which extends some twenty miles from east to west, about half as wide as it is long, and is one hundred and ten feet above White river. The soil is black or gray. Beneath, in digging wells, beds of clay inclosing fragments of wood, alternate with bands of fine sand, inducing the belief that this was once the bottom of a lake. The present growth of timber is generally young, showing that not many years ago this area was a prairie.

Three mounds, a short distance north of the village, are probably artificial and relics of the "Mound Builders." Time did not allow an examination.

South of Otwell, in section 20, township 1 south, range 6 west, Mr. Wm. Davenport reports finding a log of sweet gum (liquidambar) in a well forty-eight feet below the surface.

DAVENPORT'S WELL.

Soil and modified loess.....	5 ft. 0 in.
Yellow and red clay.....	6 ft. 0 in.
Blue clay with layers of sand.....	30 ft. 0 in.
Blue clay inclosing drift wood.....	2 ft. 0 in.
Blue mud and sticks.....	7 ft. 0 in.
	50 ft. 0 in.

At nearly an equal depth on an adjoining farm was found a black walnut log. These trees are still natives.

In the Davenport neighborhood the coal seams were not being worked. They were reported as furnishing a fair article of coal, with thickness varying from one to two and a half feet. The different localities are marked on the map. I was told that the coal formerly worked on Demette farm, northwest quarter section 27, township 1 south, range 6 west, and dug to in a well on Trayler's land, section 2, township 1 south, range 7 west, was at each of these places over four feet thick.

A small seam near the top of the hills is referred to L. Commencing thirty-five feet below this, Mr. J. Dillon dug and bored, on southeast quarter southwest quarter section 28, township 1 south, range 6 west, and, at a depth of thirty-five feet below, found K; thus determining the space between at seventy feet. Just above the lower coal, his auger passed through a layer of "very hard stone," supposed to be the cherty lime rock over K, which crops out in Flat creek two miles below. At one opening on this farm L is reported to be five feet thick.

The "White Sulphur Springs," Captain J. F. Townsend, proprietor, situated on the northwest quarter section 33, township — south, range — west, flow out at crevices in the limestone roof of coal K. The water has the medicinal qualities peculiar to white sulphur springs. It has been found to be a specific in many chronic diseases. Comfortable quarters are fitted up in which to entertain invalids. On the same farm, Captain Townsend has worked seam K, having a thickness of two feet eight inches. The coal is sulphurous.

South and west of the "sulphur springs," K rapidly mounts the conglomerate ridge. Seam A (or possibly a seam intermediate between K and A) is found in the valleys and ravines. It yields a rich, glossy-black coal, breaking with splintery fracture, and free from dust. The overlying roof-slate is highly bituminous. At several localities it changes into a laminated cannel coal, which is rich in gas

and burns with a flame of great volume. If transportation was convenient this cannel coal would be valuable to the gas maker, and for torches, kindlings, etc., etc. One of the best exposures is here added, taken on the land of G. W. Thomas, southeast quarter section 31, township 1 south, range 6 west.

SECTION AT THOMAS' MILL.

Slope, covered.....	
Soft laminated sandstone.....	8 ft. 0 in.
Silicious and argillaceous shale.....	4 ft. 10 in.
Blue clay shale.....	0 ft. 6 in.
Dark slate, with scales, teeth, and spines of <i>Petrodus occidentalis</i> , and <i>Discina</i> ..	1 ft. 6 in.
Black bituminous sheetty slate.....	0 ft. 10 in.
Cannel coal.....	1 ft. 1 in.
Hard coal, some sulphur.....	2 ft. 0 in.
	—————3 ft. 1 in.
Fire clay, to branch.....	5 ft. 3 in.
	—————
	24 ft. 0 in.

The cannel coal and bituminous slate above contains leaves, stems, and stalks of ferns, *Cordaïtes borassifolia*, *Lingula umbonata*, and *Discina nitida*, with a few fragments of Crinoid stems and of *Productus*.

In the region between Flat creek and Patoka river, coal seams are visible or have been worked at the following localities, viz.:

Anderson's, northeast quarter Sec. 27, T. 1 S., R. 6 W.
 DeMotte's, northwest quarter Sec. 27, T. 1 S., R. 6 W.
 Davenport's, south half Sec. 27, T. 1 S., R. 6 W.
 Rodarnell, northwest quarter Sec. 28, T. 1 S., R. 6 W.
 Dillon, southwest quarter Sec. 28, T. 1 S., R. 6 W.
 Townsend, northwest quarter Sec. 33, T. 1 S., R. 6 W.
 Carpenter, northeast quarter Sec. 31, T. 1 S., R. 6 W.
 G. W. Thomas, southeast qr. Sec. 31, T. 1 S., R. 6 W.
 Taylor & Davis, Sec. 25, T. 1 S., R. 7 W.

Garrison, northwest quarter Sec. 4, T. 2 S., R. 6 W.
Davidson, southwest quarter Sec. 4, T. 2 S., R. 6 W.
Taylor, northeast quarter Sec. 8, T. 2 S., R. 6 W.
Wolfe, southwest quarter Sec. 8, T. 2 S., R. 6 W.
Case, northeast quarter Sec. 17, T. 2 S., R. 6 W.
"Copperas factory," N. W. qr. Sec. 18, T. 2 S., R. 6 W.

These coals rarely attain a thickness of more than two and a half feet except at localities heretofore mentioned.

"Miller's Ague Spring," section 5, township 1 south, range 6 west, is locally known as a "cure" for that disease. The waters are a saline chalybeate, flowing out of ferruginous beds of sandstone. Their qualities are highly esteemed by those who have tried them.

"Milburn's Spring," T. C. Milburn, proprietor, situate on southeast quarter section 35, township 1 south, range 7 west, has a high reputation in that vicinity as a remedy for diseases of the stomach, bowels, kidneys and of the skin. It is generally known as "the ague cure," but is reputed as still more efficacious in derangements of the liver and digestive organs. Many certificates from reputable persons indicate especial virtue in cases of gravel and rheumatism. At the time of my visit not less than twenty persons were drinking the water, and it was being hauled away so extensively as to almost exhaust the receiving cask. It contains salts of soda, magnesia and iron, with traces of bromine and arsenic.

The spring flows out at about the level of coal K, the shales and roof stones of which are near by. Beneath, the ferruginous and massive conglomerates are seen, and are well developed. A short distance to the west, this rock is suddenly depressed below the surface within the space of a quarter of a mile, and we find a mass of shales and soapstones thrown against and upon the tilted strata of sand rock. In a field adjoining the spring were found some good casts of *Calamites*, *Sigillaria* (3 Sp.), *Lepidodendron*, (2 Sp.), and *Trigonocarpum olivæformis*. Indications of coal K were noticed in ravines, but no openings were visible.

At Winslow, coal K is well developed, and has long been worked to supply mills and forges. It is a caking coal, good for steam use, and, by selecting the upper or lower divisions, furnishes an article pretty free from sulphur and well liked by blacksmiths. Moulton's bank is worked at two openings, with four other outcrops on the same section 28, township 1 south, range 7 west.

SECTION AT MOULTON'S BANK.

Slope, thin to heavy sandstones.....	40 ft. 0 in.
Limestone.....	1 ft. 8 in.
Calcareous shale.....	4 ft. to 0 ft. 0 in.
Black sheety slate with iron stones.....	2 ft. 4 in.
Coal K :	
Good blacksmith coal.....	1 ft. 0 in.
Steam coal, pyritous part's..	4 ft. 7 in.
Good blacksmith coal.....	1 ft. 0 in.
	————— 5 ft. 7 in.
Fire clay.....	3 ft. 5 in.
	————— 53 ft. 0 in.

At this mine, the seam rises to the east one foot in a distance of forty feet ; and dips at the same rate to the west.

Thomas' bank, on the Crowe estate, south half southwest quarter section 29, township 1 south, range 7 west, was also being mined. The dip here was west southwest at the rate of fifty feet to the mile.

SECTION AT F. THOMAS' BANK.

Slope .....	.....
Limestone with <i>Productus</i> and <i>Spirifer</i> ...	1 ft. 3 in.
Calcareous clay.....	1 ft. 6 in.
Black bituminous sheety slate.....	1 ft. 8 in.
Coal K :	
Good smiths' coal.....	1 ft. 2 in.
Steam coal.....	1 ft. 6 in.
Caking coal.....	1 ft. 6 in.
	————— 4 ft. 2 in.
Fire clay.....	3 ft. 5 in.
	————— 12 ft. 0 in.

I am indebted to Mr. Charles DeBruler for much information as to these coals, and also about outcrops on sections 20, 21, 22 and 32, which were covered and not visible; the reported thickness varying from three to five feet.

In part the flora and fauna of this vicinity are sub-tropical in their affinities. Persimmon bush and sweet gum are common. Canebrakes formerly existed. Tobacco grows well. Mr. DeBruler, a few years ago met and killed two black "cotton-mouth" snakes north of Winslow, and Mr. Corn, a few miles southeast, captured another. They were of a mottled, rusty, yellow color above, copper colored beneath, and clear white about and under the mouth.

South of Winslow coal outcrops, or has been discovered in wells, as follows, viz.:

	THICKNESS.	
	Ft.	In.
Wells & Whitmen, L, Sec. 1, T. 1 S, R. 8 W.....	4	8
Unknown, K, Sec. 2, T 1 S., R. 8 W.....	3	9
Hathaway, L, Sec. 6, T. 1 S., R. 7 W.....(?)	4	0
On line of L. and St. L. R. R.:		
Thomson, L(?), S. E. qr. Sec. 13, T. 2 S, R. 8 W.....	3	0
Skinner, K, W. half Sec. 18, T. 2 S., R. 7 W.....		
——, K, N. W. qr. Sec. 18, T. 2 S., R. 7 W.....		
Pancake, K, N. W. qr. Sec. 17, T. 2 S., R. 7 W.....	?	2
Beer, K, S. W. qr. Sec. 17, T. 2 S., R. 7 W...represented	3	6
Ashby, K, N. E. qr. Sec. 17, T. 2 S., R. 7 W. represented	4	0
Morgan, K, S. W. qr. Sec. 17, T. 2 S., R. 7. W. represented	3	0
Beech, K, W. half Sec. 21, T. 2 S., R. 7 W...represented	3	6
Wilder, K, S. W. qr. Sec. 21, T. 2 S., R. 7 W. represented	3	0
White heirs, A, S. E. qr. Sec. 16, T. 2 S., R 7 W.....	4	7
Corn, A, S. W. qr. Sec. 15, T. 2 S., R. 7 W.....	4	0

Wells and Whitman's bank has been considerably worked for local use. The product is a light caking coal, free from sulphur, which burns with a white flame, leaving a gray ash and no clinker.

SECTION AT WELLS AND WHITMAN'S BANK.

Silicious shales, with carbonaceous and clay partings.....	12 ft. 0 in.
Soapstone fern bed, with <i>Neuropteris rarinervis</i> , <i>N. hirsuta</i> , <i>N. Collinsii</i> , <i>Alethopteris Serlii</i> , <i>Pecopteris arborescens</i> . <i>P.</i> (——) <i>Cordaitea</i> , and <i>Calamites</i>	0 ft. 8 in.
Coal L:	
Slaty coal.....	0 ft. 4 in.
Pure laminated.....	0 ft. 6 in.
Cubic, gas coal.....	1 ft. 2 in.
Choice angular bright.....	2 ft. 8 in.
	4 ft. 8 in.
Fire clay, dark bituminous.....	0 ft. 9 in.
Fire clay, white stigmarial.....	4 ft. 3 in.
Soapstone, with calcareous balls and bands.	2 ft. 3 in.
Soapstone and silicious shales	12 ft. 0 in.
	36 ft. 7 in.

Hathaway's bank, section 6, township 1 south, range 7 west, was not opened, but from weathered fragments and accompanying material, the coal was very similar to Wells and Whitman's. From this point west, seam L is probably persistent along the line of the Louisville and St. Louis Railroad. To the east, coal L has been eroded, and was not seen again until met on the highest hill tops at Pikesville, one hundred and eighty feet above Hathaway's. This shows the amount of erosive power necessary to remove the absent strata in the intervening area, and also the rapidity with which this seam ascends to the highlands.

The coals K, on the head of Barren creek, were not visible and could not be measured. They are reported as varying from two and a half to four feet. The only measurement possible was taken near the quarter post between sections 17 and 20, where the thickness was less than two feet.

Many outcrops of A are found down in ravines bordering the Patoka, in the northeast part of township 2 south, range 7 west. Generally the seam is thin ; but at several localities it is widened up by layers of coal, separated by clay or slaty partings, which indicate that the upper divisions have been transported from other localities. The following, taken on White's land, north half southeast quarter section 16, township 2 south, range 7 west, begins under the "rock house" sand rock :

SECTION AT WHITE'S BANK.

Aluminous shale.....	10 to 15 ft. 0 in.
Black sheety slate.....	1 ft. 10 in.
Coal A :	
Splinty coal, with clay and	
slate parting.....	3 ft. 4 in.
Good splinty cancell.	1 ft. 3 in.
	4 ft. 7 in.
Fire clay.....	5 ft. 0 in.
	26 ft. 5 in.

A natural bridge on Jackson Corn's land, southwest quarter southeast quarter section 16, township 2 south, range 7 west, is formed by a small branch passing beneath a ledge of "rock house" sandstone. It is symmetrical, thirty feet long, ten feet wide with a chord of twenty feet.

Coal A is found on adjoining land below the water level.

SECTION AT CORN'S.

Slope	
Coarse, soft disintegrating sand-	
stone.....	10 to 30 ft. 0 in.
Massive sandstone with "rock	
houses".....	50 ft. 0 in.
Aluminous shale.....	10 to 15 ft. 0 in.
Black sheety slate.....	2 ft. 0 in.
Coal A.....	4 ft. 6 in.
	101 ft. 6 in.

Pikesville is located on high land geologically, as well as topographically. Coal L is found in wells near the surface, K crops out on the side hill, and the place of A is but little below the level of low water in Patoka river. The following approximate section was taken by barometric measurement:

SECTION AT PIKESVILLE.

Soil and loess loam.....	20 ft. 0 in.
Silicious shale and soapstone.....	18 ft. 0 in.
Coal L.....	1 ft. 6 in.
Fire clay.....	3 ft. 0 in.
Silicious and clay shale.....	30 ft. 0 in.
Ochre and black slate.....	3 ft. 0 in.
Coal K.....	1 to 3 ft. 0 in.
Laminated sandstone.....	20 ft. 0 in.
Massive sandstone.....	60 to 40 ft. 0 in.
Aluminous shale in Patoka river (estimated).....	10 to 30 ft. 0 in.
Place of coal A.....	.....
	168 ft. 6 in.

A spring flowing out near the roof slate of coal K in the northern part of the village, is locally known as an "ague cure." The water contains sulphates of iron, alumina and perhaps magnesia.

East and southeast from Pikesville, we find a succession of hills and deep narrow ravines. Coal L is rarely met with. K soon mounts to the hill tops, and at the dividing ridge between Patoka and the Ohio runs out or is eroded. A is found near the water level in the deep valleys. Intermediate between K and A, the conglomerate sandstone is well developed. The upper division, coarse and disintegrating, is sometimes sufficiently compact to furnish grindstones of excellent quality, as on the north half section 28, township 2 south, range 6 west. The "massive division" from sixty to eighty feet thick is often precipitous, and on north half section 28, the underlying aluminous shales have

been excavated by Rocky (or Paint) creek, so as to form "rock houses;" one of which has a sufficient capacity and was often used as a shelter by a small tribe of Indians. In this cave were found a number of incipient "Indian mortars"—round cavities drilled into the solid rock by pebbles from the upper stratum agitated by drops of water trickling from the roof-stones.

SECTION ON J. CASE'S LAND, NORTHWEST QUARTER SECTION
28, TOWNSHIP 2 SOUTH, RANGE 6 WEST.

Slope .....	.....
Massive sandstone.....	60 ft. 0 in.
Aluminous shale, "rock houses".....	8 ft. 0 in.
Soapstone.....	3 ft. 0 in.
Limestone.....	0 ft. 8 in.
Black slate	2 ft. 0 in.
Coal A :	
Compact splinty cannel.....	1 ft. 1 in.
Block coal.....	0 ft. 5 in.
	1 ft. 6 in.
Fire clay to Rocky creek.....	3 ft. 6 in.
	78 ft. 8 in.

Near the southeast corner of section 28, township 2 south, range 6 west, Dr. DeTar, and other citizens, have made examinations, and found an excellent article of cannel, superior to any that I have seen in the State. The seam is eight inches thick, resting upon another of bright, compact, semi-block coal, one and a half feet thick. This last will pay all expenses for mining, and leave the cannel as clear profit. The roof is a highly bituminous cannel-like slate, which on further exploration may answer for many uses to which cannel coal is devoted. On failure of the Pennsylvania wells, coal oil may be distilled from this slate at a cost not exceeding fifty cents per gallon.

SECTION AT DE TAR'S BANK.

Loess	25 ft. 0 in.
Slope, covered.....	50 ft. 0 in.
Massive sand rock.....	45 ft. 0 in.
Aluminous shale with iron nodules.....	16 ft. 0 in.
Ferruginous limestone.....	1 ft. 1 in.
Ochre.....	0 ft. 10 in.
Black cannel-like slate.....	2 ft. 0 in.
Coal A :	
Choice cannel coal.....	0 ft. 8 in.
Bright compact splinty-	
cannel.....	1 ft. 1 in.
Block coal.....	0 ft. 6 in.
	2 ft. 3 in.
Fire clay to Rocky run.....	2 ft. 6 in.
	134 ft. 8 in.

The above cannel coal is rich in volatile matter, burns with a great volume of flame, does not snap as cannel slates usually do, but leaves a considerable amount of white ash. An outcrop, a short distance southeast from Dr. DeTar's bank, indicated that another coal seam at least one and a half feet thick there existed between K and A, and about thirty feet above the latter. The connecting strata could not be seen, and consequently nothing more than a probability can be expressed. This is sustained by the fact, that in Warrick, near the southwest corner of Pike county, such a state of affairs does exist.

In the valley of Cup creek, coal has been mined to a small extent at several banks. The thickness ranges from two to five and a half feet, and averages two feet four inches.

COAL NEAR PIKEVILLE.

		THICKNESS.	
		Ft.	In.
In the village.....	L	1	6
Stephens, Sec. 20, T. 2 S., R. 6 W.....	L ?	1	4
Miller, Sec. 21, T. 2 S., R. 6 W.....	L ?	0	8
Miller, Sec. 21, T. 2 S., R. 6 W.....	K	1	7
Case, Sec. 28, T. 2 S., R. 6 W.....	A	1	6
Unknown, W. half Sec. 28, T. 2 S., R. 6 W.....	A	2	0
DeTar, S. E. qr. Sec. 28, T. 2 S., R. 6 W.....	A	2	3
Todrank, N. E. qr. Sec. 30, T. 2 S., R. 6 W.....	K ?	.....	.....
Beling, S. W. qr. Sec. 30, T. 2 S., R. 6 W.....	.....	.....	.....
Spradley, W. half Sec. 27, T. 2 S., R. 6 W. (rep'd)	K	2	6
Stone, S. W. qr. Sec. 27, T. 2 S., R. 6 W.....	.....	.....	.....
Powers, S. W. qr. Sec. 24, T. 2 S., R. 7 W. (rep'd)	K	3	0
Miller, S. E. qr. Sec. 24, T. 2 S., R. 7 W.....	K	.....	.....
Abshire, N. E. qr. Sec. 25, T. 2 S., R. 8 W. (rep'd)....	K	2	0
Dutton, S. W. qr. Sec. 25, T. 2 S., R. 7 W. (rep'd)....	K	2	4

These coals are generally semi-block, with partings often half a foot or more in thickness of good block coal. The thin seams are pure; where thickened are usually pyritous.

Stendal was named by the Rev. W. Baumeister after his native city the capital of the province of Altmark, Prussia. It is situated upon a narrow ridge or "backbone" which separates the valley of Cup creek from the basin of South Patoka. This ridge, commencing near Winslow, continues in a south westerly direction beyond Stendal to the southern boundary of the county in almost a direct line, and is nearly the western margin of the conglomerate. It was the ancient Indian war path leading from the upper Wabash to the Ohio near Troy. When first visited by white men, this trail was distinct and beaten as if it had been long and much used. By it one may traverse this wild and hilly region on a level road or highway from one hundred and twenty to two hundred and ten feet above the adjoining water beds. On the farm of Mr. Baumeister, northeast quarter section 11, and northwest quarter section 12, town-G. R.—18

ship 3 south, range 7 west, are frequent outcrops of seam K well up to the top of the hills. The coal is block, but only a few inches thick. The black slate above K is rich in fish remains, amongst which were found *Petrodus occidentalis*, (teeth, scales and spines,) fish bones and coprolites, and fragments of a buckler-headed crustacean. The decomposed pyritous nodules and limestones, parting with their excess of sulphur, have formed several sulphates which are seen on the slope below, viz.: copperas, sulphate of lime crystallized, and also a fine clay, beautiful as meerschaum, which roasted, leaves a pure clear white residuum. To the east of Stendal the country is a succession of valleys and hills supported by the "massive" sand rock. Below, near the level of the streams, coal A is found. This sand rock has all the good qualities necessary to insure a large industry in quarrying and preparing blocks for building, when a demand for fire proof material of great endurance arises.

Near the southeastern corner and generally along the southern boundary of the county, the strata dip rapidly toward the Ohio river. Coal K soon approaches and then passes under the level of the streams. Here another seam comes in a few feet below K, between that seam and A, as may be seen by the following section, taken on the Beardsly farm, section 29, township 3 south, range 6 west, in Warrick county, and about a mile south of the county line :

SECTION AT BEARDSLY'S BANK, WARRICK COUNTY.

Thin bedded sandstone.....	10 ft. 0 in.
Ferruginous limestone.....	1 ft. 0 in.
Aluminous shale.....	4 ft. 0 in.
Dark shale.....	1 ft. 8 in.
Black slate with fish remains and <i>Pleurotomaria carbonaria</i> , <i>Macrocheilus paludinæformis</i> , <i>M. primogenius</i> , <i>M. fusiformis</i> , <i>Petrodus occidentalis</i> , <i>Orthoceras Rushensis</i> , <i>Aviculopecten rectilateraria</i> , and <i>Chonetes mesoloba</i>	0 ft. 6 in.

Black slate filled with large bowlders or "pot-stones" containing <i>Edestus vorax</i> , <i>Allorisma</i> ———, <i>Nautilus decoratus</i> , <i>N.</i> (sp.), <i>Bellerophon carbonarius</i> , <i>B. percarinatus</i> , <i>Cyathaxonia prolifera</i> , <i>Chonetes</i> (2 sp.), <i>Productus semireticu-</i> <i>latus</i> , <i>Spirifer cameratus</i> , <i>S. lineatus</i> , etc., etc.....	0 ft. 10 in.
Coal K, caking.....	1 ft. 8 in.
Fire clay.....	4 ft. 0 in.
Soapstone and shale with iron nodules.	4 ft. 2 in.
Coal (I ?) pyritous.....	2 ft. 2 in.
Fire clay.....	3 ft. 0 in.
	33 ft. 0 in.

COAL NEAR STENDAL.

Martin, S. E. quarter Sec. 4, T. 3 S., R. 6 W.
 Hillmyer, S. E. quarter Sec. 9, T. 3 S., R. 6 W.
 ———, N. E. quarter Sec. 8, T. 3 S., R. 6 W.
 Sakel, west half Sec. 8, T. 3 S., R. 6 W.
 Myer, S. W. quarter Sec. 7, T. 3 S., R. 6 W.
 Bartle, N. W. quarter Sec. 18, T. 3 S., R. 6 W.
 Fark, S. E. quarter Sec. 16, T. 3 S., R. 6 W.
 Doetker, S. E. quarter Sec. 21, T. 3 S., R. 6 W.
 Taylor, S. W. quarter Sec. 21, T. 3 S., R. 6 W.
 Case, N. E. quarter Sec. 20, T. 3 S., R. 6 W.
 Blake, S. W. quarter Sec. 1, T. 3 S., R. 7 W.
 Beazlee, N. W. quarter Sec. 11, T. 3 S., R. 7 W.
 Henke, S. E. quarter Sec. 10, T. 3 S., R. 7 W.
 Baumeister, N. W. quarter Sec. 11, T. 3 S., R. 7 W.
 Brust, N. W. quarter Sec. 12, T. 3 S., R. 7 W.
 McKen, S. E. quarter Sec. 12, T. 3 S., R. 7 W.
 Gille, N. W. quarter Sec. 13, T. 3 S., R. 7 W.
 Powers, S. W. quarter, Sec. 14, T. 3 S., R. 7 W.

These coals vary from semi-block to caking, and range from one and a half to five and a half feet in thickness with an average of two and a half feet. More or less sulphur is generally present.

Going west from Stendal, we find the western front of the conglomerate wall fretted with small spurs which project still farther into the coal basin. These spurs and intermediate valleys existed before the era of coal K. We find this seam deposited thinly on the crests and side of the hills, but thickening as it descends to the dividing valleys, and especially as it rapidly dips westward to the basin of South Patoka, on the head of which it develops an average thickness of four feet two inches. Considerable quantities have been dug. The product is a bright caking coal. The pyrite is banded and may be easily removed in mining.

The following exhibit of outcrops on the Powers and Tevault farms, sections 16 and 17, township 3 south, range 7 west, shows the accompanying strata, viz.:

POWERS-TEVAULT SECTION.

Magnesian limestone.....	6 ft. 0 in.
Aluminous shale.....	1 ft. 0 in.
Black sheety slate.....	2 ft. 6 in.
Coal K..	4 ft. 2 in.
Silicious shale.....	5 ft. 4 in.
Argillaceous sand rock, to Buck creek..	10 ft. 0 in.
	33 ft. 3 in.

The limestone above appears to be highly magnesian, and contains the following fossils, viz.: *Productus punctatus*, *P. semireticulatus*, *Chonetes mesoloba*, *C. ———*, *Eumicrotis Hawni* (?), *Nautilus decoratus*, and *Allorisma*.

I visited several openings at the Warrick county line, in sections 28 and 29, township 3 south, range 7 west, worked by Miller, Skegs and Gentry, where the following was taken:

SECTION AT MILLER'S BANK.

Slope.....	20 ft. 0 in.
Thin bedded sandstone.....	8 ft. 0 in.
Quarry sandrock.....	10 ft. 0 in.

Silicious shale.....	9 ft. 0 in.
Potters' clay with iron stones.....	1 ft. 0 in.
Ferruginous limestone, with <i>Spirifer</i> <i>cameratus</i> , <i>S. lineatus</i> , <i>Productus</i> <i>punctatus</i> , <i>P. costatus</i> , <i>Chonetes</i> , and an Articulate (sp.?).....	1 ft. 8 in.
Ferruginous paints.....	0 ft. 7 in.
Gray clay shale.....	2 ft. 2 in.
Ochreous clay.....	0 ft. 6 in.
Black bituminous sheety slate.....	2 ft. 5 in.
Coal K:	
Slaty coal.....	0 ft. 4 in.
Fair coal.....	1 ft. 0 in.
Pyritous coal.....	1 ft. 2 in.
Good coal.....	2 ft. 0 in.
	4 ft. 6 in.
Fire clay to creek.....	4 ft. 0 in.
	66 ft. 10 in.

At Pleasantville I was much indebted to Rev. John Ferguson for hospitality, information and guidance. This enabled me to visit many outcrops, which otherwise my limited time would have compelled me to pass unnoticed.

COALS EAST OF PLEASANTVILLE.

	THICKNESS.
	Ft. In.
Farmer, S. W. qr. Sec. 6, T. 3 S., R. 7 W.....K	
McClary, S. E. qr. Sec. 7, T. 3 S., R. 7 W.....K 4 • 2	
McClary, S. W. qr. Sec. 8, T. 3 S., R. 7 W.....K 4 0	
Roy, N. W. qr. Sec. 18, T. 3 S., R. 7 W.....K 4 0	
Lance, N. W. qr. Sec. 18, T. 3 S., R. 7 W.....K 4 0?	
Fleming, N. E. qr. Sec. 18, T. 3 S., R. 7 W.....K 4 0?	
Powers, S. E. qr. Sec. 17, T. 3 S., R. 7 W.....K 4 4	
Tevault, S. W. qr. Sec. 16, T. 3 S., R. 7 W.....K 4 2	
Sprinkle, N. W. qr. Sec. 21, T. 3 S., R. 7 W.....K 4 1	
Miller, S. E. qr. Sec. 21, T. 3 S., R. 7 W.....K 3 6	
Ferguson, (well) S. W. qr. Sec. 21, T. 3 S., R. 7 W..K 4 0?	
DePriest, (well) S. E. qr. Sec. 20, T. 3 S., R. 7 W..K 4 0?	

	THICKNESS
	Ft. In.
McKinney, N. E. qr. Sec. 19, T. 3 S., R. 7 W.....K	
Miller, N. E. qr. Sec. 29, T. 3 S., R. 7 W.....K 4 6	
Skeggs, N. W. qr. Sec. 29, T. 3 S., R. 7 W.....K 4 2	
Hamilton, N. W. qr. Sec. 1, T. 3 S., R. 8 W.....K 5 0?	
Hamilton, N. W. qr. Sec. 1, T. 3 S., R. 8 W.....K 5 6?	

Northeast from Pleasantville, the yellow limestone roof of K is in thin bedded strata, and is quarried and used for walling wells, etc. Partings between the laminæ are covered with *Chonetes*. Immediately at the village, seam K with a dark limestone roof, passes below the surface. A short distance west, seam L is seen. At Tyring's bank, northeast quarter section 23, its usual roof material is removed and replaced with coarse sand rock as will be seen by the following exhibit, viz.:

SECTION AT TYRING'S BANK.

Soil and modified drift.....	15 ft. 0 in.
Loose soft sandstone.....	8 ft. 0 in.
Quarry sandstone, coarse, ferruginous.	7 ft. 0 in.
Coal L.....	2 ft. 4 in. to 3 ft. 0 in.
Fire clay.....	3 ft. 0 in.
Covered.....	27 ft. 0 in.
Limestone roof of K.....	2 ft. 0 in.
Covered.....	5 ft. 0 in.
Black sheety slate of K in creek.....	.....
	70 ft. 0 in.

The product of this bank is a rich caking coal, which burns with a clear flame, leaves a white ash without a linker, and is much sought after by blacksmiths.

Good clay iron stones, suitable for the manufacture of ochreous paints, were noticed in considerable quantities in southeast quarter southeast quarter section 22, and near center of section 21, township 3 south, range 8 west. Further exploration alone would determine whether the quantity would be sufficient to command the attention of

iron makers. The surrounding slopes are deeply covered. No rocky outcrops were seen. It is believed that this band of paint stones represents the place of coal M, which is reported in wells at this horizon.

To the south and to the west, a line of conical hills and narrow ridges, capped with massive argillaceous limestone, separates the basin of erosion in which is collected the water of South Patoka from the basins of the Wabash and Ohio rivers. From the summit of one of these, which is marked on the map McGregor hill, section 9, township 3 south, range 8 west, a beautiful view is spread out. The cup-shaped valley of the South Patoka lies 175 feet below. To the southeast of Snake knob, seven miles distant, is seen Detney Hill, twelve miles southsouthwest. Stendal, eleven miles due east. To the northeast the alluvial plain, gently terraced with modified drift, is backed by the hills near Winslow. It is a scene at once interesting and attractive—a mighty record of the past, of noble currents and cycling ages. A witness that time is long.

The following section combines measurements taken at McGregor hill above mentioned with those of Snake knob, section 34, township 3 south, range 8 west, on Captain Fowler's farm, in Warrick County, the latter in the second column. The two sections are here brought together for the purpose of showing the equivalence of strata at stations separated by a space of more than three miles :

SECTION AT M'GREGOR HILL AND SNAKE KNOB.

	Ft. In.		Ft. In.	
Soil and clay.....	5	0	15	0
Limestone, argillaceous, clinky.....	6	0	3	6
Space covered, place of upper <i>rash coal</i>	6	0	15	0
Limestone, compact, clinky.....	3	0	4	0
Clay shale and nodules.....	4	0	2	0
Place of lower <i>rash coal</i>	?		?	
Fire clay, buff.....	2	4	2	6
Sandstone, coarse, red.....	8	0	15	0
Silicious shale with carbonaceous partings.....	16	6	8	0

Argillaceous shale with pyritous partings.....	8	0	12	0
"Black clod," rotten slate.....	2	0	1	3
Coal <i>N</i> , choice white ash gas coal.....	1	0	1	1
Fire clay.....	3	0	3	2
Silicious shale and thin bedded sandstone.....	20	0	18	0
Calcareous and clay iron stones, place of coal <i>M</i> . ?			?	
Clay shale mostly covered to the level of coal				
<i>L</i> at nearest point measured by barometer...	72	0	70	0
			156	10 170 6

The argillaceous lime rock in the above section is sometimes widened up to a thickness of eight or ten feet. Compact and not easily eroded, it proved, along this its apparent eastern limit, a bulwark against which the ancient currents could not always prevail. And hence the conical hills so capped. Crevices are found between, and cavities beneath; the immense blocks undermined and thrown out of place. These cavities, at the time of the first settlement of this region, were the winter resort of the snakes that occupied an area of from three to nine miles around. Here the venomous tribes, with consorting sub-families and friends, would collect in autumn, remain torpid through the winter, and then, wakened by the sunny smiles of spring, go forth to their old summer homes.

Snake knob was a famous resort. Peter Ferguson, an early pioneer, noticed serpents in the fall gathering here from all parts within a compass of several miles. He collected a squad of neighbors, and dug them out in winter, when torpid, killing over one hundred, mostly rattlesnakes, but including a few chicken-snakes. The animals in their torpid condition could not offer resistance, and were only revived by the brilliant sunlight enough to writhe a little when cast out into the snow. After this campaign at Snake knob, a similar massacre at McGregor hill and another at a station a few miles east, allowing a range of nine to twelve square miles for each community, the rattlesnake family was nearly exterminated. They are now rare. 'Mr. P.

Ferguson, during his lifetime, killed a rattlesnake having twenty-nine rattles and a button, indicating an age of thirty years. Others have seen and known of their capture when armored with rattle-rings numbering fifteen, twenty, twenty-one to twenty-five. After passing beyond an age of twelve years these rings are always much worn on the under side, especially in stony or sandy regions. A monster of this species was killed near Pleasantville in 1871, and brought to the village for exhibition. It weighed fifty pounds on the warehouse scales.

In addition to the openings at Tying's bank, coal L was formerly worked on M. Parker's land, northeast quarter southwest quarter section 14, township 3 south, range 8 west, and on the Mosier farm, section 4, same township and range. The reported thickness at each of these banks was three and a half to four feet. At Bell's, section 17, the seam was less than two feet thick.

Near Arcadia, coal K has been worked for smiths' use at Lemaster's bank, and is four feet thick. At other farms in this vicinity it has been dug to in wells, and evidently underlies a considerable area.

COALS NEAR ARCADIA.

Lemaster, S. W. quarter Sec. 25, T. 2 S., R. 8 W.

Ashby, S. E. quarter Sec. 25, T. 2 S., R. 8 W.

Gentry, S. W. quarter Sec. 35, T. 2 S., R. 8 W.

Sandusky, S. E. quarter Sec. 26, T. 2 S., R. 8 W.

Werth, S. E. quarter Sec. 22, T. 2 S., R. 8 W.

Continuing northwardly, K descends and passes below the bed of the streams, and coal L is discovered above the water level. On the line of the Louisville and St. Louis railway this seam probably becomes persistent, and at G. W. Massey's bank, northeast quarter section 4, township 2 south, range 8 west, where the Evansville Straight Line Railroad crosses Patoka river, Dr. D. D. Owen reported the thickness at over ten feet, and said that it was one of the thickest coals that he had seen in the State. At Thomas

Martin's bank, coal L is not less generously thickened up. The product is a rich caking coal, which burns with a slightly-tinted flame, leaving a white ash, but no clinker.

SECTION AT MARTIN'S BANK, NORTH HALF SECTION 9,
TOWNSHIP 2 SOUTH, RANGE 8 WEST.

Soil, clay etc.....	18 ft. 0 in.
Black slate.....	1 ft. 0 in.
Soft slate (rotten coal?)	1 ft 6 in.
Coal M.....	1 ft 1 in.
	————— 2 ft. 7 in.
Fire clay.....	4 ft. 6 in.
Silicious shales and soapstone covered (measured by barometer).....	57 ft. 7 in.
Soapstone with ferns.....	4 to 1 ft. 0 in.
Coal L:	
Slaty coal.....	0 ft. 4 in.
Laminated coal.....	2 ft. 6 in.
Soft black slate.....	0 ft. 4 in.
Good smith coal.....	1 ft. 6 in.
White clay and soft coal	0 ft. 2 in.
Good smith coal.....	2 ft. 6 in.
Rash pyritous coal (not seen)	2 ft. 0 in.
	————— 9 ft. 2 in.
Fire clay.....	4 ft. 9 in.
	————— 98 ft. 0 in.

The floor of the entry at Martin's bank was covered with water at the time of my visit. A complete measurement could not be effected. The seam at this and Massey's bank may be worked up to a thickness of six or seven feet of fair to choice coal, after making allowance for impurities. It is probable that on more extensive work it will be found that these coals dip rapidly to the northwest at a rate of not less than twenty to forty feet to the mile.

West of the county line Andrew Hargrave has erected a

lime kiln and burns the "gray limestone" mentioned by Dr. D. D. Owen in his report.* This rock is probably equivalent to the deposit of a similar nature on top of Snake knob and McGregor hill. Formerly its eastern limit was miles beyond this locality, as blocks of limestone, rounded, grooved and singularly cut by water, are found on the farms of G. W. Massey and Horace Williams, two miles distant.

ECONOMICAL GEOLOGY.

COAL.

The coals of this county are generally caking. In quantity they are fully up to the average of similar coals in the Western States. An examination of the foregoing section and details shows from frequency of out crop, that they are of great persistence. They are the thickest beds of such grand extent that I have seen, and would seriously try the carrying capacity of *all* the railways that have ever been projected in the county. The present demand is limited to local supply. No shafts have been sunk. Openings have only been made on natural outcrops. These are enough to show, that, with facilities for transportation at hand the coals of Pike county could pay off our great national debt, and still leave a handsome profit to the owners.

CLAYS.

The loess sands and yellow clays furnish good material for bricks. The fire clays underlying the coals are almost as valuable as the fuel resting upon them. The future demands fire proof buildings. From these clays will be made window and door casings, cornice and ornamental coping, at once durable, handsome and incombustible. Good potters' clay may be obtained by weathering this deposit, or from the glacial and lacustrine clays in the northern part of the county.

*D. D. Owen, Geological Recon., Ind.

IRON.

Silicious ores are found amongst the conglomerate sandstones, north and east of Pikesville. They are not desirable. The ferruginous limestone quarried from the bed of the canal south, and along the banks of White river north of Petersburg, will furnish a flux rich in iron to mix with the specular ores of Missouri. The clay iron stones in the southern part of the county will make good paints; and when abundant, as in the southwestern corner, they will merit the attention of iron makers.

OTHER METALS.

Small quantities of gold and copper are found in the modified drift and clays of the glacial age. The particles are minute and of no importance. Occasional specimens of lead ore are found; but oftener "plants" are made by swindlers who guide innocent parties to the deposit and deceive the unwary. The red men had no knowledge of metallurgy, even the simplest: yet fifty places are pointed out by Indian story, as "lead and silver mines." Prof. Orton naively remarks on this subject; "If the red man owes any malice to the race that has dispossessed him of his hunting grounds, he may take a grim satisfaction in contemplating the arduous and unrequited toil to which his idle tales have doomed the laziest of his oppressors." No evidence was seen that indicated natural deposits of either lead or silver ore in this county, and we may add, that their existence is highly improbable if not impossible. Small crystals of sulphuret of zinc were sometimes seen in the iron stone nodules and septaria.

BUILDING STONE.

The massive member of the subcarboniferous sandstone so well developed for miles in every direction about Pikesville, furnishes the best of material for masonry. Natural out crops exhibit a wonderful capacity for withstanding the disintegrating influences of air and moisture. Characteristically, it

is known as a fire stone, and may be used for hearths of furnaces and rolling mill ovens. Good coal-measure sand rock is found near Highbanks, at Hawthorn and Centreville. The limestone roof of coal K, has been used for foundations. It is generally argillaceous, and when so, will not bear exposure.

SOIL.

The soil of the northern half of the county consists of dark colored alluvium, sandy loams, and loess. It is generally productive. Good crops of wheat, oats, corn and grass are raised. White river bottoms, are remarkable for luxuriant crops of corn. Patoka bottoms consisting of impalpable sands, etc., washed from the loess hills, are impervious to air and moisture. Parched by drouth, or overwhelmed by rain falls, they require underdraining, which will remedy both these difficulties; when so improved, the "coming farmer" will undoubtedly irrigate these broad flats from the river which flows a few feet below.

In the basin south of Patoka, the earth is highly charged with mineral salts, and has the peculiar red hue of soils which contain the decomposed iron stones of the mountain limestone. Here tobacco grows well. I am informed by experts that the "leaf" will compare favorably with the best Kentucky or Missouri product. Tobacco land, exceeding the Connecticut valley in productiveness, may be bought at less than thirty dollars per acre.

The areas throughout the county from one to two hundred feet above the water courses, are elevated beyond the level of sudden changes in temperature. They are exempt from biting frosts, and are specially adapted to the growth of fruit. Peaches and pears are nearly as reliable as corn or wheat. The fruit is large, beautifully colored, and highly fragrant.

SPRINGS AND WELLS.

North of Patoka river, the water derived from this source is fair to good. South of that stream, and in the conglom-

erate region about Pikesville, the waters are highly charged with mineral salts, unpleasant to the taste, and, in times of drouth, cause inflammatory diseases. Persons having a due regard to comfort and health, construct cisterns. The rain fall furnishes an abundant supply of pure water. Pools are easily made in small basins or ravines, to insure comfort and health to farm animals.

MEDICINAL SPRINGS.

The "White Sulphur Spring," Captain Townsend proprietor, has all the good qualities belonging to springs of this kind. The water is not so highly saline as those of Orange county, but is equally efficaceous in chronic diseases of the liver and digestive organs. The Ague Chalybeates, near Pikesville are locally well known.

Millburn spring, near Winslow, according to a proximate analysis by Dr. DeTar, contains, in addition to the sulphates of magnesia, alumina, lime and iron, a small amount of arsenite of iron and a trace of bromine. These and other unknown ingredients have effected many cures. Certificates are published representing this water as nearly a specific in gravel and diseases of the spleen.

The acidulous water of Coats' spring, near Centerville is locally well esteemed. It is believed to act on the secretions generally, and was highly recommended by a corpulent gentleman on the spot, to his brother "fat-men."

TIMBER.

The finest growth of White Oak and Poplar timber that I have ever seen, is found in a belt lying one to three miles north of the Patoka. Trees five feet in diameter, with perfect trunks fifty or more feet in length, were common, while monsters of much larger growth are not unusual. A giant Hickory, northwest of Centerville, on section 8, township 1 south, range 9 west, was measured with the assistance of Rev. L. Wilson, and found to be over five feet in diameter three feet above the ground. The trunk was of great uniformity,

maintaining that size to a hight of sixty feet without limbs; and for size challenges its kind throughout the world. Choice uncultured White Oaks are abundant in the southeast corner of the county.

ANTIQUITIES.

An oblong mound south of Petersburg, whether natural or artificial, contains implements and bones of our predecessors. A few regular mounds are seen near Pleasantville and Otwell. The high sand-bars capping the bluffs of White river, have been used as places of ancient sepulture. Axes made from dark granite of the boulder drift, ornaments of northern variegated soapstone, and large spear-heads made of flint, are probably relics of the Mound-Builder.

Thanks are due to the following gentlemen, and many others, for information, assistance, and guidance, viz.: Messrs. Posey, Mr. Shandy, G. Morgan, Rev. Martin, Dr. Thornton, R. P. Hawthorn, and Editors Posey and Leslie, at Petersburg; Rev. L. Wilson, at Centerville; Dr. Daniels, James Case, T. Case, S. Traylor, Captain Townsend, at Otwell; Dr. De Tar, at Pikesville; Z. Whitman, C. De Bruler, and others, at Winslow; Rev. W. Baumeister, at Stendal; Rev. Ferguson and Captain Fowler, at Pleasantville, and G. W. Massey, County Commissioner.

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EUGENE, INDIANA, October 22, 1872.

PROFESSOR E. T. COX,
State Geologist :

SIR:—In accordance with your request, I have made a hurried reconnoissance of the counties of Jasper, White, Carroll, Wabash, Miami, and Howard—giving, on an average, something less than two days to each—and submit the following report. It is not presumed that it will exhibit such precision in its outlines as a more thorough survey will obtain; and which would tend to develop the resources of that portion of our State.

JOHN COLLETT.

GEOLOGICAL RECONNOISSANCE
OF
Jasper, White, Carroll, Cass, Miami, Wabash
AND
Howard Counties.

BY PROF. JOHN COLLETT,
ASSISTANT STATE GEOLOGIST.

GENERAL FEATURES.

Excepting Jasper, the counties named are situated in the hydrographic basin of the Wabash river, being generally in its present or ancient valley, which in extent, from east to west, is more than half the entire width of the State. Jasper county lies in the valley of the Iroquois and Kankakee rivers.

As the Wabash valley is approached from Indianapolis by way of the Lafayette and Indianapolis Railroad, the descent from the ridge dividing the Wabash and White river valleys is quite rapid.

The Wabash valley is a broad plane, marked by a deep, black, peaty soil, and is so nearly level as to require in many places artificial drainage. When this is done it becomes highly fertile.

The table land, which is about three hundred feet above White river at Indianapolis and nearly four hundred feet above the Wabash at Lafayette, is evidently the undisturbed floor of the boulder drift. Below the peaty surface is found the clays and polished, rounded and striated stems of that epoch. Massive granitic and metamorphic boulders are found deeply buried in these, but no boulders are seen on the surface.

These features are conspicuous along the road near Whitestown and from the water-tank at Lebanon, to, and a short distance beyond Hazelrig. From this point the surface is gently undulating with an occasional boulder protruding through the surface on the knobs and prairies, as rapidly descending toward the Wabash river, hills and valleys are noticed, boulders are more frequently seen; occasional beds of gravel occur until near Lafayette, where will be found relics of the boulder drift, with heavy beds of ancient river alluvium; and high up on the terraced bluffs are marked indications of the different levels of the river during past ages.

To the north and northwest of Lafayette, we find the reverse of these conditions. First, alluvial bottom; second, terraces and terraced prairies of sandy alluvial loam underlaid with gravel; third, a gently undulating level with many boulders on or near the surface; and lastly, a level plateau nearly four hundred feet above the level of the Wabash river at Lafayette, on which boulders are not seen, and which is the floor of the glacial drift.

From these facts, I infer that the Wabash and its tributaries have, in the past, traversed all the region between the summit levels, embracing a belt from ten to fifteen miles in width, on either side of its present channel; and they have eroded the great valley through which the river flows, to a depth varying from 0 to 400 feet, with an average width of twenty miles, and that the system of hills and valleys that border this river are not the effect of direct creative agency but were produced by the erosive force of waters. It was by the same force also that the gigantic boulders which,

deeply imbedded in the plastic clays that mark the close of the drift epoch, were uncovered and exposed to view.

The ridge forming the limit of the valley of the Wabash on the north is not so well defined as that on the south. It commences on the west line in Benton county and passes thence in a northeasterly direction across portions of Benton, Jasper and White counties, and thence east to counties not yet examined, and is in places cut through by the Tippecanoe river and other streams.

Generally this ridge forms the dividing line between the basins of the Wabash and Kankakee rivers, and its northern slope is belted with low sand terraces and beds of sand that mark the outline of what once was "Old Lake Kankakee," as named by Prof. F. H. Bradley in the Illinois Geological Reports, volume IV.

Profiles of the Louisville and Chicago Railway show that it would not require a very deep cut canal to bring the waters of the Kankakee into the Tippecanoe river, and thus drain that vast region of swamps and slashes, and at the same time, by the increased volume of water, protracted in its flow by the difference of altitude, add much to the navigability of the Wabash river.

JASPER COUNTY.

The southwestern half of this county is a gently rolling prairie of black loamy soil. In the northern and north-eastern portion, the soil is sandy with oak openings and slashy prairies interspersed with sandy knolls and ridges, and is in a wild state of nature scarcely disturbed by the hand of man.

The whole county is underlayed by beds of bowlder drift, which varies in depth from twenty feet, in the valley of the Iriquois river, to nearly two hundred feet at some of the higher ridges.

The rocky exposures of this county are wholly of the Devonian and Silurian ages. Considerable fragments of black slate and small bits of coal are met with in digging

wells in the boulder clays, which indicate that the sub-carboniferous sandstone and possibly the outline of the carboniferous age, at one time, extended beyond this county to the north, but were eroded during the great ice flow from the northwest.

The following section, made from the observation of isolated localities, will serve to give a general idea of the rocks of this county :

CONNECTED SECTION.

Soil and loam.....	2 to 5.00 ft.
Boulder drift.....	20 to 200.00 ft.
" Waverly " or knob sandstone.....	15.00 ft.
Louisville-Delphi black slate.....	62.00 ft.
Coarse, white sand rock (local).....	0 to 15.00 ft.
Devonian limestone.....	5 to 2.00 ft.
Silurian limestone (exposed).....	8.00 ft.
Silurian limestone, porous with cavities filled with petroleum and gas (in bore).....	855.00 ft.
Total.....	1162.00 ft.

The highest rocks in the geological series occur near the southern boundary of the county, a short distance north of Remington. They are an argillaceous sandstone, having an exposure of about twelve feet in Jordan's Grove, on Carpenter's creek. Stratigraphically, it is the lower division of the Waverly or Kent sandstone; sometimes considered a member of the Devonian. It is better known as the sub-conglomerate sandstone.

In former years, this stone was quarried for local use for foundations, but is not now in work.

At the only exposure, it was irregularly bedded, and from the only fragments visible would not compare favorably with other stone found in the county.

A short distance further north, on Carpenter's creek, the Louisville-Delphi black slate is seen in the bluff underlying the above mentioned sandstone. The exposure measures

twenty-three feet, is slightly glazed with bituminous matter, and the odor of petroleum is perceptible. During the oil excitement a bore was here put down, and the slate was found to extend forty feet below the surface, making the total thickness sixty-three feet. It is probable that the erosive force of the boulder drift had thinned this bed not less than thirty feet.

About four miles west, at Allen quarry, on a branch of Carpenter's creek, a thin bed of limestone is extensively worked for building purposes. Several dwelling houses and barns of this material give a pleasing variety to the architecture of the vicinity. The stone seems to weather well. No fossils were found by which to determine its horizon.

At Rensselaer, the county seat, the Iroquois river flows over a bed of limestone. A few corals and a fragmentary specimen of *Pentramiles galeatus* show that it belongs to the upper silurian age. This limestone is here cherty, and neither fit for burning into lime nor for building purposes. A short distance below the town it is purer, and has been burned to lime to supply the local market. A short distance above town, near the old mill dam, thin beds of limestone of the Devonian age are seen in the low banks of the river. A few broken fossils were seen, among which were *Cyathophylloid corals*, *Atrypa aspera*, *A. reticularis*, and *Spirifer euritines*.

This bed is the only rocky exposure seen on the Iroquois river in Jasper county. It is an original ridge of deposit, having a line of strike from N. N. E. to S. S. E., and from surface indications veering to the northeast a few miles north from Rensselaer. A new exposure in the western part of the town still records the mighty effects of the great ice flow which resulted in the boulder drift.

The surface is rutted and polished, while the scratches show that the direction of the current was a little west of south. Three miles southeast of the town is the Phillips' sand rock quarry, owned by J. C. Van Rensselaer. It is a coarse grit, containing a few pebbles, and is very similar to the conglomerate sand rock. It has been used for build-

ing and other purposes at Rensselaer with good results. Being in a considerable degree fire, as well as weather proof, it is an important part of the mineral wealth of the county.

Water-worn casts of a few plants of the carboniferous age were noticed in the stone.

The Logansport and Peoria Railroad passes from east to west along the southern part of the county, and the Continental Railway Company has graded the bed of its road from Rensselaer to a connection with the Louisville and Chicago Railroad, on which they intend to lay steel rails as early as the season will permit. The latter road is intended to be a great through line from New York to Omaha, with a branch road from Rensselaer to Chicago, and is thought by those most interested, will prove to be a road of great advantage to the commercial interests of the county.

A reliable bed of gravel, of about twenty-five acres in area, was noticed on the farm of Mr. Thompson, on section 16, township 29, range 6, a few miles north of the town, and another bed of about two acres was seen on the opposite side of the creek. These, together with the abundant limestones about the county seat, afford ample facilities for the construction of gravel roads.

Bog ores of iron are abundant in the northern part of the county. The area of deposit, after careful examination by Mr. S. P. Thompson, being estimated as follows:

Township 30 north, range 7.....	700 acres.
Township 30 north, range 6.....	500 acres.
Township 30 north, range 5.....	500 acres.
Township 31 north, range 6.....	1500 acres.
Township 31 north, range 7.....	500 acres.
Township 32 north, range 5.....	1000 acres.
Township 32 north, range 6.....	500 acres.
Township 32 north, range 7.....	500 acres.

Many other beds of smaller area are known to exist.

These ores are collected in a soluble state by the waters of sloughs and ponds, in the center or lower part of which they are found in comparatively pure layers, deposited as

the waters are evaporated in dry seasons. The beds are generally from one to two and a half feet below the surface of the ground, and from five to six inches thick (with a reported thickness, in some places, of two and two and a half feet.)

In 1870 Mr. L. Glazebrook dug and shipped from San Pierre station, on the Louisville, New Albany and Chicago Railroad, 500 tons of ore, part being from Jasper county and part from Starke county. Other parties dug and shipped from the same point from 300 to 800 tons. The price obtained was \$3 per ton delivered aboard the cars, which paid well for digging, and less than three miles hauling to the railroad.

The ore was taken to the Planet Furnace, in Clay county, but, on account of the high rates of freight (three dollars per ton, as I am informed,) imposed by the railroad, the business was abandoned.

The ore is pure, and makes, by admixture with the rich ores of Lake Superior, a very desirable quality of metal; and with reasonable freights, large quantities of the ore would be in demand.

The divide which separates the Kankakee and Iroquois rivers, is a succession of low ridges of pure yellow or white sand, interspersed with swampy valleys from one hundred to four hundred yards in width, indicating ancient river channels.

The soil in these valleys is peaty and of no very great depth, and is underlaid by a deposit of white sand. The timber consists of White Oak, Hickory, and, on fair soil, Burr Oak.

The numerous river beds above mentioned show the extent of the region traversed by the Kankakee and Iroquois rivers before finding a fixed channel, when "old Lake Kankakee" was first drained off.

ECONOMICAL GEOLOGY.

It will be seen from the introductory remarks that Jasper county contains a large body of highly productive lands.

The principal products are corn, oats, hay, grass, and wheat. Herds of cattle and hogs are pastured and fed for market. In the northern part of the county there are large bodies of wild land; oak openings, sand ridges, and low meadows alternating. This soil is not of the best; but, subdued and improved by German and Swedish emigrants, it yields this hardy and frugal people satisfactory returns. These lands may be bought in quantity at from \$3 to \$5 per acre.

Timber: A narrow strip of deep, rich, alluvial soil, from one to two miles in width, along the southern margin of the Kankakee, is well timbered and highly productive. Groves and skirts of timber are found along the water courses, which have been found sufficient to supply the demand for all purposes. Much attention is given to growing hedges, and soon the large farms will be inclosed by live fences of Osage Orange, which I am informed succeed well.

Minerals: The area of the Bog ores of iron is large and the quality good. Means of transportation is all that is required to develop a large income from this now profitless treasure.

The sand rock near the county seat is of excellent quality; equal to any in the State for foundations of buildings and other heavy masonry. The whole county is underlaid with limestone of the upper silurian age, known to be several hundred feet thick, and it is believed that future demand will justify shafting for this valuable stone for building purposes. The surface outcrops furnish abundance of stone to be burned into lime.

Mineral Springs: A number of mineral springs near Rensselaer were visited, the waters of which experience has determined to be highly medicinal. Among them are some white sulphur springs, which, in a malarious climate, are worthy of attention. Half a mile east of the county seat, a well that was bored to the depth of 800 feet discharges a large volume of sulphuretted water. This well is supplied from a crevice about one hundred and eighty feet below the surface. Another well in the court house yard, that was

bored with a "diamond drill," furnishes a supply of water near the surface. The "core" brought up by the drill furnishes an interesting view of the rock below.

Petroleum: It has long been known that Jasper county affords abundant evidences of the presence of Petroleum. In the geological map of Indiana, published by Dr. Brown, former State Geologist, this county was included in a small area marked "the oil region." At low water, oil oozes from crevices and partings in the limestone rocks at Rensselaer; and from a well sunk to the depth of fifteen feet in this rock, several gallons of oil were obtained, and large lumps of bitumen (desiccated petroleum) were found in the excavation made for the railroad track a few miles east of town, some of which were hardened into asphaltum. These evidences of its presence induced search for the precious fluid, and several bores were put down. The bores at the county seat determined the existence of a bed of porous lime rock from eighteen to thirty feet thick, just below the thin bedded limestone which underlies the black slate. None of these wells yielded any appreciable quantity of oil, and it is not probable that a paying well will be obtained, as the fluid is so diffused in the small pores of the rock as to render its collection very difficult, which is also the case at Chicago, where bores were made in a similar rock.

Small quantities of inflammable gas escapes from each of these bores, and also from many natural fissures. A well put down to a depth of one hundred feet at Francisville, discharges a large volume of gas, which inflamed, serves to light up an area of many acres, and may be utilized for household, culinary and illuminating purposes.

Antiquities: Not many evidences by which to determine the character of its former inhabitants were seen. Spear and arrow heads of an unusual form and of a glossy chert, seen only in Tennessee, are here found; also, highly polished stone axes and scrapers.

A mound, on the east side of the Iroquois river, about four miles northeast of the county seat, is the only relic of the

Mound-Builders that was seen ; it was nearly ten feet high, forty feet in diameter and contained ashes, bones and shells.

WHITE COUNTY.

This county adjoins Jasper on the east ; and is, generally of a similar nature. The southern and western portions are mostly prairies where the surface has been modified by action with a fertile and productive soil. Good crops of corn, wheat and meadow grass are raised ; blue grass is indigenous and with some care furnishes the richest permanent pastures. The northern part of the county is more sandy, and large herds of cattle are annually pastured during the summer months.

East of the Tippecanoe river the land is more rolling and a large quantity of choice oak timber stands ready to be converted to various uses for future improvements.

The Tippecanoe river flows in a southerly direction, and its tributaries, the two Metanonongs, flow in an easterly direction through the county. All the streams are full of fishes and are the favorite haunts of the disciples of Izaak Walton.

The rocky formations consist of shales and limestones of the Devonian age, overlying the upper silurian lime rock.

CONNECTED SECTION, WHITE COUNTY.

Soil and fluviatile drift.....	5 to	60 ft.
Boulder drift.....	10 to	150 ft.
Black slate.....		81 ft.
Thin bedded limestone.....	10 to	2 ft.
Silicious limestone.....	2 to	12 ft.
		305 ft.

The Tippecanoe river is one of the most important features in this county, not only as a means of wealth but as well in a geological point of view. To agencies connected with it are due effects which have largely moulded the surface configuration. Immediately after the close of the lake

period when the waters of old Lake Kankakee and Lake Iroquois had been partially drained away, this vein commenced extending along the valley to the north by erosion. This mode of action necessarily contemplates an erratic channel. We consequently find large beds of fluviatile drift along its banks, and at Monticello trunks of cedar and other woods have been met, in digging wells, down to a depth of forty feet.

The following section of a bed of fluviatile drift, opposite Norway, gives a general exhibit, with features at intervals indicating a probability, at least, of lacustrine phenomena :

SECTION OPPOSITE NORWAY.

Yellow sand.....	6 ft.
Gray sand, lacustrine.....	22 ft.
Blue clay, slightly laminated.....	4 ft.
Coarse gravel.....	16 ft.
Compact clay, laminated.....	5 ft.
Gravel, coarse.....	18 ft.
Hard sandy clay.....	4 ft.
Clayey gravel.....	10 ft.
Black slate.....	10 ft.
Coarse silicious limestone, with Devonian fossils and odor of petroleum.....	2 ft.
	97 ft.

The foregoing is thrown up against and backed by the black slate, and affords a clue to the history of the long past worthy of a careful study.

Just above the Norway mill-dam is a bold exposure of the black slate, which affords the following section :

SECTION AT NORWAY DAM.

Fluviatile drift, covering upper divi- sion of black slate.....	30 ft. 0 in.
Black slate.....	40 ft. 0 in.
Black slate, odor of petroleum.....	18 ft. 0 in.

Clay.....	0 ft. 6 in.
Black slate with mineral tar.....	5 ft. 0 in.
White clay.....	0 ft. 6 in.
Black aluminous slate.....	5 ft. 0 in.
Concretionary band.....	2 ft. 0 in.
Blue shale.....	5 ft. 0 in.
Gray argillaceous shale.....	4 ft. 0 in.
Devonian limestone, containing <i>Zaphrentis gigas</i> , <i>Z. Rafinesquii</i> , <i>Pentamerus athyris</i> , to bed of river.....	2 ft. 0 in.
	112 ft. 0 in.

At the upper part of this outcrop, in a ravine, a shaft was put down through the lower division of the black slate in pursuit of coal. No coal was found.

At Lowe's quarry, near the mouth of the Monon, stone is quarried for local use, from a thin bedded deposit of Devonian lime rock, containing *Pentamerus* and *Crinoid* stems. The rock is cherty, and not of satisfactory quality; some highly silicious layers, composed in part of silicate of lime, is a good fine stone.

Ball's quarry, one mile west, is of similar stone, and has been used for similar purposes. Still farther up the Monon, and four miles east of Bradford, Mr. Larkin Lowe quarries, from the bed of the river, stone which is burned for local use. It produces a fair article of lime. Owing to a rapid rise of strata going west from the valley of the Tippecanoe, a lower strata and belt of lime is exposed. *Pentamerus* and *legathephyllleice* corals indicate the upper beds of silurian age. A short distance to the west, heavy beds of the same rocks are seen along the river banks, with pits and cavities filled with petroleum and bitumen.

On the bank of the same stream, at Bradford, is an outcrop of a limestone very similar to that burned so successfully at Delphi, having a thickness of about twelve feet. Although not so pure as the deposit at Delphi, a fair article of lime is produced. It contains *Pentamerus*, *Orthocera* and *crinoid* stems.

The strata seem to dip from this point in almost every direction, perhaps with an exception in favor of areas to the N. N. E., as rocks stratigraphically higher are seen east, west, and south.

ECONOMICAL GEOLOGY.

The alluvial soils along the Wabash, Tippecanoe, and other rivers, with the terrace prairie land in the southwest part of the county, form a large area of fertile land, on which good crops of corn, oats, and grass, are raised. The northern part of the county is sandy and is not much improved, but yields pasture free to all, beyond the wants of all the cattle of the vicinage.

Large quantities of wild grass is annually made into hay and shipped by rail to neighboring cities.

Near the center of the county, and west of the Tippecanoe river, is found a loamy soil, once interrupted by slashes and ponds, but when drained is well adapted to stock raising. Fine herds of cattle were noticed. Blue grass (*poa pratensis*) is indigenous, and with a little care forms a strong sward.

TIMBER.

A sufficient for past and present wants has been obtained in the "oak openings" and along the streams. East of Monticello, I am informed, timber is abundant and of excellent quality.

MINERALS.

Some money has been spent in this county shafting for coal, but, of course, without result, as the rocks found at the surface in this county, are from five hundred to nine hundred feet below the coal measures. Petroleum is noticed in the porous limestone, but so minutely distributed that, although the quantity is large, it is not possible to collect it in paying quantities.

Below the soil and drift material, an unlimited supply of stone is known to exist. At no distant day it will be brought to the surface by shafts and utilized.

ROAD MATERIAL.

Gravel for road-making, of the best quality, is abundant. At a little expense, good roads may be made.

BOG ORE.

In the sloughs and swampy prairies in the north and northeastern parts, large beds of bog ore of iron are known to exist. These were formerly baked without smelting at the Logansport forge, but the long transportation of the ore by wagon soon put an end to the enterprise.

WATER POWER.

The Tippecanoe river flows from north to south, nearly through the center of the county. The water is pure and clear. Pebbles may be seen at great depths beneath the surface. Fish are as plentiful as in our more northern lakelets.

In size it is as large as the Wabash where it flows into that river; and in its flow through White county, the engineers engaged in locating the Wabash and Erie Canal found there was a descent of ninety feet, or nearly four feet to the mile.

A stream of this size, with this amount of fall, is a mighty source of power, and although now flowing idly by, yet in the early future, we may expect to see these idle waters vexed by dams and turbines into vigorous laborers. The power is sufficient for grist, saw, paper, cotton, or woolen mills, and generally two or more mills may be driven by a single dam, while, by reason of the rapid descent, a dam may, with advantage, be located every two or three miles along the river.

Water is the cheapest possible power. A dam, alone, is needed, which ought not to exceed the cost of a steam engine of an equal power. The expense of running, cartage, engineers, and skilled employes, is avoided.

The situation comprises health, comfort and cheap food.

and cheap homes for operatives. It is believed these facilities ought to command the attention of capitalists, and that in value they are equal to a coal bed occupying a space commensurate with the valley of the Tippecanoe river. Minimum supply of water, 17,000 cubic feet a minute; maximum, for nine months of the year, 47,000 cubic feet.

ANTIQUITIES.

This county was the favorite home of the Mound Builders. Their tumuli are seen along the river wherever good farm land was found convenient to water, river transportation, etc.

At the village of Bedford was noticed a cluster of these mounds, nearly ten feet in height. One of the largest has been excavated and used as a lime kiln. Quite a number of mounds, three to five feet high, were noticed where the Monticello road crosses Little Mound creek.

CARROLL COUNTY.

At the close of the glacial epoch this county was probably a level plain. Since that time the Wabash river and its tributaries have eroded a very considerable amount of clays and boulders deposited by the great ice flow, forming a valley in this natural plain from ten to twenty miles wide, and from 100 to 200 feet in depth, and cutting their channel down into the underlying rocks about ninety feet. Hence a great variety of soil is found to exist, ranging from the stiff clays of the boulder drift, through many modifications, to the ancient and modern alluvial loams which are found on the terraces bordering these rivers.

The rocks exposed in this county belong to the Devonian and Silurian age, but it is probable that in the southern parts the subconglomerate knobstone (Waverly sandstone) will yet be found.

The following connected section, combined from measure-
G. R.—20

ments taken at several localities near Delphi and at the bluff below Pittsburg, will give a general view:

CONNECTED SECTION.

Boulder drift.....	50 to 200 ft. 0 in.
Terraces and gravel beds thrown upon and against the last.....	20 to 90 ft. 0 in.
Louisville-Delphi black slate, Devonian	50 ft. 0 in.
White alluvium, hard.....	2 ft. 0 in.
Black slate.....	18 ft. 0 in.
Clay shale, light color.....	4 ft. 0 in.
Blue slate.....	8 ft. 0 in.
Band of large concretions	2 ft. 0 in.
Black shale	12 ft. 0 in.
Band of concretions	1 ft. 6 in.
Drab shale.....	10 ft. 0 in.
Gray shale.....	3 ft. 6 in.
Devonian limestone.....	22 ft. 0 in.
Pentamerous limestone, silicious.....	30 ft. 0 in.
Petroleum limestone, silicious.....	20 ft. 0 in.

474 ft. 0 in.

The black slate is a prominent feature of the foregoing section. Although the exposures were disconnected, yet combined, they afford a view reaching from the bottom to within a few feet of the upper layer. The name is established in geological nomenclature, but is hardly significant. The slate is, at exposures, a brownish-gray shale with considerable iron finely disseminated. Bituminous matter is present, with petroleum in small quantities, and bituminous tar or albertite in fissures and partings. No fossils were noticed in the upper beds. In the lower beds, Mr. George Vandeventer, reports having found some fern leaves. Breaking open the concretions locally known as "boulders," obscurely marked trunks of *Lepidodendron* and *Stigmaria* were found, the spines of the latter containing petroleum.

Both were probably of new species. In another boulder, I found large teeth of a fish belonging to the shark family. This horizon is rich in fish remains, and further exploration will richly reward the scientific worker.

Immediately below the slate, a coarse impure limestone is found, twenty-two feet thick when seen. It is of little economic value, but has been used for foundations and rough walls. It contains *Cyathophylloid* corals, *Spirifer auritisma*, *Atrypa reticularis* and *Chonetes setigara*.

The pentamerous bed is an irregular deposit, variable in its mode of occurrence and thickness, evidently deposited by currents flowing across inequalities in the surface of regularly deposited rocks below. It is generally found thrown upon or against these inequalities, and consequently this deposit exhibits remarkable peculiarities of false bedding. The lines of deposit are never horizontal, sometimes nearly vertical, and at all angles between their directions. This phenomenon is often pointed at as the effect of subsidence and upheaval, but may be easily and more truthfully accounted for by studying the mode of deposit peculiar to this bed. The stone is crowded with casts and fossils, the animal matter being wholly removed, as *Pentamerous Knightii* large and very abundant, *Halysites catenulata*, corals, crinoid stems and *Bryozoans*.

The lower part of the bed is burned for lime, and furnishes an article of high grade in the market. The lower bed is but partially explored at the quarries. It is similar to the last, but being free from animal and mineral impurities, presents a superior article of lime. Only a few fossils have been found, all being of the Niagara epoch of the Silurian age.

ECONOMIC GEOLOGY.

About two-thirds of the area of Carroll county is upland variety, the modified material of the boulder drift. Descending from the highest table land, 250 to 270 feet above the Wabash, we find on approaching that river the soil becomes

more loamy, with beaches and gravel terraces, marking the ancient channel of the river from eighty to one hundred and ten feet above its present bed. The whole county was originally clothed with a good growth of excellent timber, including White, Black and Red Oak, Walnut, Poplar and Maple. Good crops of corn, wheat, oats and hay are produced. Blue grass thrives, and apples, sound and of large size, were abundant.

BRICK CLAYS.

The clays of this county are largely composed of the pulverized *debris* of the black slate. This gives plasticity to the material, and adds a perceptible amount of iron, which paints the bricks here made, with an indelible, ruddy color. A stranger will at once notice that the city of Delphi has the appearance of a new town. Although some of the houses have been exposed to the weather for twenty-five years, the brick walls are as fresh and brightly colored as of yesterday. This building material deserves the notice of architects, as it is believed to furnish a product equal to any in the Union.

BUILDING STONE.

Good rock for this purpose is not abundant. An inferior article, quarried near, and in Delphi, the county seat, is used for foundations and rough masonry.

LIMESTONE.

Several mines are opened and extensively worked in and near Delphi for burning. The lime produced is of good quality, and is a specific article of trade known as "Delphi Lime." It sets slow, or in mechanical terms "works cool," allowing the mechanic time to spread his plaster, or lay mortar over a large space before "setting," and thus secures complete contact with adjoining surfaces. On "setting," the cement adheres well, and becomes as hard as stone, often more compact than brick. The burned stone does not air-slack readily and consequently affords ample

time to facilitate transportation. Seventy pounds of this lime, I am informed, is considered equal to eighty pounds of other Ohio or Indiana limes.

The following firms are engaged in the business, with appliances and productions as follows, viz.:

Cartwright & Co., use three common kilns, and one "Donnelson Perpetual Burning Kiln." Their product for the current year will amount to seventy-five thousand bushels. Reported cost of manufacture by common kilns, sixteen cents, and with patent kiln, ten cents per bushel.

At Springfield, Illinois, I am informed, that lime from this firm was used in the construction of sewer walls in the place of hydraulic cement. At the expiration of one year, the wall, although exposed to water, was found to be compact and in a satisfactory condition.

E. W. Hubbard & Co. mine their stone from the lower member of the Pentamerous limestone, at their location, about twenty feet thick. The strata dip in every direction, and at one part of the mine are nearly vertical. A band of porous stone is seen near the water level containing petroleum, which oozes out on exposure to the warmth of an October sun.

Hubbard & Co. have twenty common kilns and two "Monitor Perpetual Burners," Pelton's patent. The capacity of the common kilns amounts to 150,000 bushels (of seventy pounds) per annum. The common kilns are now only occasionally in work. The capacity of the two "Monitor Kilns" is estimated at 500 bushels a day, and are intended to run nine months in a year. The greatest product in one year is reported at 150,000 bushels.

F. Shelly & Co. use four common kilns having a capacity for burning 160,000 bushels per annum; one "Shelly's Perpetual Burner," which burns 200 bushels a day, or 66,000 bushels per annum.

The expense for mining is 35 cents per yard; of burning by common kiln 16 cents per bushel, and by patent kiln 10 cents per bushel, of 70 pounds. The product for last year was 150,000 bushels. Specimens from all the different

mines were secured for the State cabinet for exhibition and analysis.

PAINT.

The black slate, at many localities in the United States, has been pulverized and used as a paint or for plastic slate roofing. Here this deposit is well suited for this purpose, and unusual facilities are offered for mining the crude material and for manufacturing by means of water-power. B. F. Tea, in the year 1866, bought of experienced manufacturers a lot of fixtures for the manufacture of fire and water-proof paint, and commenced the business a short distance south of Delphi. The slate was ground up as quarried from the exposed bluffs without any washing or other purifying process. The capacity of the mill was reported at 50 to 60 barrels per day. Large amounts were manufactured and sold at a handsome profit, until the sudden death of the proprietor put an end to the enterprise.

A specimen of roof paint, in a trying situation, showed good qualities after six years exposure to sunshine and storm. Another mill established by G. Vandeventer Esq., in 1867, just below Pittsburg on the west bank of the Wabash, after grinding a few barrels of paint, was suspended on account of a disagreement amongst members of the company. The slate at Delphi and vicinity is exposed along outcrops, amounting to about ten miles. Thickness of the bed 100 feet. An unlimited supply may be obtained.

ROAD MATERIAL.

Gravel is abundant and of the best quality. Beds fifty to sixty feet thick are seen at several localities along the river. It is derived from the boulder drift. Experience has shown this to be an excellent article for making roads.

WATER POWER.

A short distance above Delphi, the Wabash river is dammed to supply the Wabash and Erie canal. After serving this

purpose, a large surplus of water is left for manufacturing purposes. The present year, 1872, is known as the greatest season of drouth ever known. During this year, the amount supplied by the canal company to mills at different points is as follows, viz.:

Delphi	4,000 cubic feet.
Pittsburg.....	4,000 cubic feet.
Lafayette.....	4,000 cubic feet.
Not used.....	3,000 cubic feet.

For an ordinary season of low water the quantity *not* used amounts to 10,000 cubic feet. This supply is quadrupled during two-thirds of the year. It may be seen that this power, cheap, certain and effective, will prove a great source of wealth, and that this large amount of unused power will soon be utilized. Amount of fall secured by Pittsburg dam is thirteen feet. Connected with this power are woolen, saw and grist mills, at Pittsburg, and flax, paper and other mills at Delphi.

CASS COUNTY.

The grand features of this county are similar to those of Carroll. The Wabash river flows from east to west near the center, and Eel river, from the northeast, enters the same at Logansport, the county town. Hence there is found bordering these streams a large area of loamy alluvial soil of great excellence. Large crops of corn and wheat are produced; the latter of superior quality. The county was originally covered with a dense growth of timber, and the quantity and quality of that still remaining, is worthy the attention of the workers in wood.

The rocks of this county are of upper Silurian age, with outlines of lower Devonian. The southern part of the county was not visited where it is probable the latter formation prevails, although generally buried beneath the drift.

CONNECTED SECTION.

Soil.....	2 to	10 ft.
Modified drift.....	10 to	20 ft.
Boulder drift.....	120 to	30 ft.
Devonian black slate, (reported).....		30 ft.
Devonian limestone.....	20 to	10 ft.
Silurian yellow limestone, local.....		11 ft.
Fire stone.....		12 ft.
Fine blue limestone.....	20 to	40 ft.
Silico magnesia limestone.....	10 to	40 ft.
		203 ft.

The common features of the drift formation are, perhaps, sufficiently described in the remarks introductory to this report, and need not be here repeated. The out-crop of black slate reported in the southern part of the county was not visited for want of time, but Mr. D. Keipert reports its occurrence on Deer creek, ten miles south of Logansport.

Richard Owen notes, in *Geology of Indiana*, 1860, an outcrop of Devonian limestone on the Cincinnati road. Southeast from Logansport another bed was seen near the southern bank of the canal, three miles east of town, rich in beautiful specimens of *Favosites gothlandica*, *F. polymorpha*, *Acervularia Davidsonii* and *A. profunda*. These fossils were found abundant, and well preserved. At Mr. D. Keipert's lime works, four and a half miles east of town, a still richer Devonian coral reef was seen, containing besides *Favosites* and *Acervularia*, also *Lucina proavia*, *cyathophylloid corals*, and a large *Gasteropod* (indt). The deposit is about ten feet thick. Two lime kilns here obtain stone beneath this bed. R. Donaldson has one "Perpetual Burner," his own patent, which is intended to run eight months in a year, and reports that he has had his kiln in constant use for six months at one time, without allowing his furnace fires to cool; capacity and product, 200 bushels per day, or

40,000 bushels per annum. At this locality, D. Keipert has a kiln of same plan and of equal capacity. The proprietors have used coal from Parke county, Indiana, and from Danville, Illinois, in their business; and after a thorough test, find that the Sand creek coal of Indiana burns more freely, is without clinker, and decidedly preferable to the Illinois coal. Mr. Keipert finds that, as a fuel for his kiln, coal is fifty per cent. cheaper than wood, and that when block coal is used, the product is fully as pure and free from color as lime from a kiln in which wood is used.

The lime costs, for quarrying, wear and tear on tools and fixtures, fuel, etc., twelve to fifteen cents per bushel of eighty pounds, and is sold at the kiln, by the car load at from eighteen to twenty cents per bushel. It is known by masons as a "hot" lime—begins to "set" quick, but requires from ten to twenty days to thoroughly harden. At each of the mines, strata, containing petroleum diffused in minute pores or collected in small crevices, are seen, and occasionally a cavity is broken into containing several pounds of bitumen. On William Dunn's land adjoining is found a bed of snow white sand stone, suitable for making glass, and also a thin stratum of lithographic stone; samples of each of these rocks were secured for the State Cabinet.

Bowen & Grayen, one mile west from Kerfoot, have a perpetual kiln, Donaldson's patent, having a capacity of 200 bushels a day, and for a year of eight months of 50,000 bushels.

The strata mined here and at the localities throughout the county, are either lower devonian or upper silurian, and almost invariably from near the junction of the two formations.

Below the lime rock beds is a thick deposit of buff colored rock, often locally called "free stone," termed in Owen's report the "silico magnesia limestone." It contains little or no lime, but in position, color, and mode of occurrence, is exactly similar to the famous buff colored stone obtained at the Anamosa quarries in Iowa, and used so extensively, and with such good architectural effect in that State. At

the weathered outcrops the stone does not make a favorable appearance. The same is true at the quarries above mentioned; but, as at the Anamosa quarries, it is believed that on uncovering the stone deeply protected from atmospheric action, good beds will be discovered. The following section at the head of Cedar Island, shows some massive bands worthy the attention of quarrymen.

SECTION AT CEDAR ISLAND.

Roughly weathered white limestone.....	4 ft. 6 in.
Irregular and amorphous stone.....	14 ft. 0 in.
Thin bedded " <i>silico magnesia</i> ".....	4 ft. 6 in.
Heavy bedded " <i>silico magnesia</i> ".....	11 ft. 6 in.
Banded limestone with petroleum and tar.....	1 ft. 6 in.
	36 ft. 0 in.

The Wabash river here flows over a solid floor, part of which indicates good quality for building purposes; while the "*silico magnesia*" limestone in the precipitous bluffs of the island is distinctly and heavily bedded, and more compact than at many other points. "Rostrum Rock," on the Indiana Reservation, on the south bank of the river, is a truncated pillar standing alone in the forest. Other quaint remnants of the *silico magnesia*, capped with white limestone, are seen in the adjoining forest, attesting at the same time the enduring qualities of the stone and the erosive power of the river. On the canal, half a mile west of Lewisburg is a very extensive bed of gravel as below noted:

SECTION NEAR LEWISBURG.

Soil and clay.....	5 ft.
Fluviatile drift.....	10 to 20 ft.
Black clay.....	14 ft.
Gray clay.....	2 to 5 ft.
Clay and gravel to canal.....	35 ft.
Gravel to river.....	20 ft.
	99 ft.

At John Castenborden's mill, on Pipe creek, one and a half miles south of Lewisburg, is a heavy bed of buff silico magnesia limestone. Precipitous outcrops confine the stream on each side, having a thickness of 15 to 20 feet. The stone is compact, may be quarried in large blocks, and has been used for foundations and for piers in the Lewisburg bridge. It is more calcareous than at other localities, seems to weather well, and contains *Pentamerus*, *Bryozoans*, and Silurian coral. One mile south of Logansport is an outcrop of stone, principally thin bedded, known as the "Fire Stone Quarry." This stone has, in an extraordinary degree, a capacity for resisting the effects of heat. It has long been used for the back-walls of fire-places in houses, and the parts exposed to excessive heat in furnaces, successfully and profitably. For the former use it would be a desirable convenience to those who still wish to enjoy the luxury of open fire-places. It contains the following fossils which assign it a position near the line separating the Silurian and Devonian formations, viz.: *Atrypa reticularis*, *A. nodostriatus*, *A. aspera?*, *Platyceras dumosum?*, *Spirifer Niagarensis*, *Calymene*, *Blumenbachii*, var. *Niagarensis*, and *Bryozoans* of the genera *Clathrepora*, *Retapora*, and *Fenestella*, with Crinoid stems, plates, etc.

John Lux has opened a quarry less than a mile further south. He obtains a stone which comes from the quarry soft and easily worked, but hardens on exposure. It is granular in structure, has much the appearance of sandstone, but on application of acids shows that it contains little or no siliceous matter. Mr. Lux reports a bed of fire stone in the bottom of his quarry.

The "silico magnesia," or buff-colored limestone mentioned as occurring at Cedar Island and on Pipe Creek, passes entirely beneath the bed of the Wabash at Logansport, but to the west this rock is soon found above the surface, and within a few miles attains a thickness of from twenty to forty feet. The quarry band is from four to twelve feet thick, and is broken by an irregular, vertical cleavage into masses containing from four to twenty cubic

feet. This stone, obtained at the Priest's and other quarries, was used in the piers of the T. W. W. Railroad bridge across the Wabash, and seems to weather well.

Still further down the river, and on the south bank, La Rosa and Nash have an extensive outcrop which is worked by ten different firms.

SECTION AT LA ROSA AND NASH'S QUARRY.

Gray porous limestone.....	40 ft. 0 in.
Shelly buff silico magnesia limestone.....	4 ft. 6 in.
Solid buff silico magnesia limestone.....	12 ft. 0 in.
Compact brown silico magnesia limestone	15 ft. 6 in.
Hard blue limestone, with odor of petroleum and streaks and masses of tar in partings and cavities to the water line.....	? ?
	72 ft. 0 in.

When the dam and mill justify systematic work and the quarry is opened so thoroughly as to discover beds unexposed to atmospheric influences, it is believed that a stone satisfactory in quality and of that beautiful neutral tint, so desirable for architectural effect, will be secured. The surface exposures at the Anamosa quarries of Iowa are not more promising than these we now find here. It is to be hoped that a tunnel driven back into the hill will discover stone equal in compactness and beauty to its Iowan equivalent.

North of the Wabash and near the Logansport and Peoria Railroad, this stone is well developed, and has been worked on the lands of Major Dunn and Mr. Watts. At Falry's quarry, a darker stone is obtained with the same carbonaceous markings and the usual odor of petroleum. A trainway, about a quarter of a mile in length, carries the product to the railroad.

Calvert's quarry, two and a half miles east of Georgetown, gives the following section, which shows the blue limestone

unconformably deposited upon the silico magnesia, with a small parting of clay. This parting is general and is often drilled to some twenty to thirty feet below the surface at Logansport for a supply of water :

SECTION AT CALVERT'S.

Gray limestone.....	10 ft. 0 in.
Clay parting.....	2 in. to 0 ft. 10 in.
Irregular bedded limestone.....	1 ft. 0 in.
Clay band filling inequalities on surface of the Argo. magnesia limestone.....	1 to 1 ft. 6 in.
Silico magnesia limestone.....	15 ft. 0 in.
	28 ft. 4 in.

Large masses of calc spar were seen at this quarry, filling pockets in the stone.

North and west from Calvert's, is Rochester's quarry, from which is obtained the stone known along the canal as the "Georgetown stone," and which has been used so extensively in the construction of abutments, piers and copings along the canal, river and different railroads. A good test example of the quality of the stone is seen in the walls and columns of the county court house which was built twenty years ago. This quarry has been worked ever since the completion of the Wabash and Erie Canal, a period of nearly forty years. About sixty acres have been exhausted, but in adjoining ones the supply is unlimited. The stone is obtained in complete slabs of large size, varying from six inches to two feet in thickness and when burned makes a fair article of white lime free from chert. In partings between the upper strata are seen millions of small shells like *Zygospira*. A stratum from two to four inches thick of lithographic stone is also found here, which experts declare to be of good quality.

Major Dunn's quarry on the Dunn homestead, was extensively worked in former times. On the opposite side of the river from La Rosa's quarry, the stone is of the same color, and may be quarried in large blocks. Stratigraph-

ically this is the most elevated expanse of the silico magnesia limestone seen in the county. From this point, the strata dip in every direction, and rapidly to the north and northeast. The hill is capped with eight to twelve feet of gray limestone, with an expanse of quarry rock thirty feet thick. On the same farm, Major Dunn showed me a locality more than five acres in extent, where the solid rock is rent by fissures from one to two feet wide and ten to thirty feet deep, having a direction generally from northeast to southwest. The same ground is also pierced with round holes, two to three feet in diameter, reaching perpendicularly down to an unknown depth. This singular phenomenon probably owes its origin to the corroding action of rain or rain water charged with carbonic acid gas.

E. N. Talbott & Co., adjoining the Dunn farm, and one and a half miles from Logansport, are most extensively engaged in the business of burning and shipping lime. They own sixty acres of land, and paid for it by mining and burning; the bed of stone is at least forty feet thick. The product is highly caustic, and has been used by the gas companies of Peoria, Pekin, Logansport and Lafayette exclusively for several years as a deodorizer. It is a good plasterer's lime when well slacked, and makes a hard, compact wall, not liable to "pop" from subsequent exposure to the air. For masons' use it is superior, making a cement in walls which is generally harder and more enduring than common bricks.

The company use, at times of extra demand, two common kilns, with a capacity of 1600 bushels a week, besides their regular and reliable patent kilns. Of these they have three—two "Monitors" and one of "Shelby's patent"—having a combined capacity for turning out 700 bushels a day for nine months of the year, or 200,000 bushels per annum. Actual product for current year, 100,000 bushels. Talbott & Co. use coal and wood for fuel in equal quantities, and find that Sand creek coal, from Parke county, Indiana, is fifty per cent. more economical than the exclusive use of wood. Their experience shows that Indiana

coal burns freer, without "lodging," and is forty per cent. cheaper and better than Illinois coal, which cakes and "clinkers" excessively. Their lime, as it comes from the kilns, costs from thirteen to fifteen cents per bushel, and sells, delivered on the cars, at twenty-three cents for eighty pounds. R. D. Eggleston, Superintendent, informed me that at the time of my visit, the company had orders for twenty car loads more than could be filled at that time.

SECTION AT TALBOTT'S MINE.

Soil	1 ft.
Fire stone.....	1 to 2 ft.
Gray limestone, with pockets and seams of calc spar, a strong odor of petroleum, and partings and masses of bitumen....	12 ft.
Same, more compact, as found in test fire.....	48 ft.
	63 ft.

The stone is compact, free from chert, obscurely laminated, and well adapted for burning.

One of the kilns mentioned above as Monitor kilns, is of great size and known as the "Mammoth Monitor." It has a furnace base 20×22 feet square, Jeler fire chamber with side draft heaters at opposite corners, ash box and "drawing" reservoir below, built of stone and fire brick; above is an iron cylinder made of tank iron, one-sixteenth of an inch thick, twenty-two feet high and fifteen feet in diameter, lined with fire brick or other non-conducting material with an oval stem pit five by eleven feet. This kiln, which the proprietors believe is not excelled by any in the Western States, has a capacity for burning 500 bushels a day, and cost, with appurtenances, \$4,000.

Logansport is well supplied with water-power. The whole volume of the Wabash river is controlled by dams and brought by canal and a race to the city, and compelled to serve its master, man. The numerous railways centering

here have erected machine shops which cover acres of land, and the walls of which, I am informed, exceed four miles in length. Timber in abundance and of superior quality for the manufacture of wagons, carriages and other agricultural machinery. These advantages are elements which insure to to this locality a broad future.

R. S. J. Green & Co., established iron works four miles east of Logansport, in the year 1856, or 1857, at the canal lock, using water leased from the canal, for motive power. The Company used bog ore from White county, which was roasted, sifted, and heated in a Catalan forge, and then hammered into blooms by machinery. The ore, by analysis, was at least sixty per cent., but by this process the product only averaged thirty-seven per cent.

The forge was in operation about a year and a-half. The maximum product for a single month was one hundred tons. The enterprise was not profitable, because of the great expense of long transportation of the ore from White county in wagons.

EDUCATIONAL.

In addition to the common school facilities, *Smithson College*, under the direction of the Universalist Church, is situated upon the summit of the commanding hill immediately west of Logansport. The college edifice at present, is only a part of an elaborate design, planned so that additions may be made from time to time, as exigencies may arise, and consists of a building one hundred and forty feet long, having a transept seventy-three feet long, all four stories high.

The kitchen and other offices adjoin, others seem detached. These furnish accommodations for eighty boarders.

Both sexes are equally welcome to the advantages of this institution.

The building is heated by steam, and lighted with gas made on the premises, thus giving extra security against the hazards of fire.

An efficient corps of professors, under the direction of President P. R. Kendall, promises thorough educational facilities.

MIAMI COUNTY.

This county is traversed from east to west by the Wabash and Eel rivers and the Mississinewa passes across the southeastern part. As a consequence a considerable part of the county is alluvial, fertile and productive as such soils usually are. The surface outlines represent the features common to the counties hereinbefore described, except that the deposits of fluviatile and bowlder drift are not so thickly laid down.

The rocks which were seen, and probably all the rocky exposures of this county, are of upper silurian age, and seem to be equivalent to the silico-magnesia limestone mentioned in the description of Cass county, and the overlying limestones; the first mentioned beds much more argillaceous than in Cass county—in some cases becoming a magnesian argillite.

The highest seam exposed is a limestone equivalent to the rocky band at Delphi in Carroll county. A light brown colored magnesian limestone, which, from false bedding, is often seen with strata dipping at every angle almost to a perpendicular. In fact this apparently disturbed condition is often referred to oscillations in the earth's crust instead of the true solution. This bed was formerly burned for lime at Duke's quarry, adjoining Peru, the county town, but the kiln is not now in use. It is crowded with skeletonized fossils, yet still retaining a sufficient modicum of animal matter to prevent the lime from so fully slackening in the short time usually allowed for that purpose by workmen. Hence, this lime is not suited for plasterers' use, unless the mortar is permitted to remain in damp vats several months before being spread upon the walls of houses. This is too slow a process for our fast age. Yet the Roman architect who built for ages, would only use

mortar which had been prepared a year or more before it would be needed by the artificer. The fossils contained were Crinoid stems, plates and heads, *Pentamerus Knightii* and *Occidentalis* ?, *Platyceras*, *Bumastis*, *Barriensis*, *Calymene Blumenbachii* var. *Niagarensis* and corals.

Beds of this stone are generally local and of no great extent but an outcrop, somewhat purer and ten or more feet in thickness, was formerly worked a mile to the north on the farm of E. H. Shirk, and appearances indicated that this stone could be found in all the intervening area. Similar beds of stone are well developed at John Trippier's, two miles east of Peru and south of the Wabash river; and at Wallack's mill on the Peru and Indianapolis Railroad, containing the fossils mentioned as occurring at Duke's quarry, with *Favosites* and *Cyathophylloid* corals, *Hulysites catenulata* and *Bryozoa*.

At both of these localities, lime is burned for exportation as well as local use. It is similar if not equal to Delphi lime, slakes perfectly, works "cool," bears transportation well, makes a strong and almost hydraulic cement, and deserves a more extended market.

Below these beds of lime rock is found stone which I have called "silico magnesia limestone," adopting the name applied to it by R. Owen (Geology of Indiana, 1860.) The upper beds are similar to those mentioned and described in my report on Cass county. A surface opening has been made at Duke's quarry in the northern part of Peru, and it is believed that although a first rate stone has not been produced yet because exposed to the action of drouth and winters for many thousand years, but when mining operations shall have been extended to parts not exposed to atmospheric influences, the product will prove much more satisfactory.

Lower beds of stone are found along the river. This is worked at Lyde's quarry, two and a half miles west of Peru, in the low bank and bottom of the river. It is distinctly laminated, or divided by partings containing pyrites and argillaceous matter. Protected from the weather, this will serve for foundations; but on exposure the argo-pyrite

decomposes, and breaks the rock into small shelly fragments. The stone quarried at Tracy's for foundations, although less argillaceous, ought not to be exposed to extreme changes of temperature and moisture. Near the mouth of the Mississinewa are extensive beds of rock suitable for building, showing an outcrop of more than one mile. On the right bank is the brick residence and well-appointed farm of Godfrey, chief (and son of the distinguished leader) of the Miami Nation of Indians. Across the valley is the Osage village, once the residence of Chief Pecan, who was distinguished as statesman and warrior, and lived to the extreme age of one hundred years, universally respected. Many Miami Indians still live in this county, descendants from the princely line of chieftains who bravely led this once powerful Nation in its ineffectual struggle for supremacy.

Ascending the Mississinewa to a point three miles east of Peru we find the "Pillared Rocks" full of geological as well as romantic interest. Here the river flows directly to the north and infringes against a solid wall of cherty silico magnesia limestone, and diverted from its course flows thence to the westward. The action of the rushing river and unequal disintegration of the rocks has carved the precipitous wall, which diverts the river's course, into a system of pillars, rounded buttresses, alcoves, chambers and overhanging sides, ever beautiful and interesting. The whole is covered with evergreen cedars. It is a picnic ground widely known and justly celebrated. In the overlying gray limestone an *Orthoceras*, two feet long, and an obscure Crinoid head, not less than six inches in diameter, were seen. The main wall of stone is straw color, the neutral tints of which contrasted well with the autumnal foliage, at the time of my visit, of scarlet, gold and crimson.

Still ascending this stream we find a wall-like precipice bounding this river on the north side. On the farm of H. H. Hahn, the following section was taken :

SECTION ON MISSISSINEWA, AT HAHN'S FARM.

Soil, sandy.....	4 ft. 0 in.
White glass and grit stone.....	10 ft. 0 in.
Porous lime rock.....	3 to 18 ft. 0 in.
Cherty laminated argillaceous limestone to river.....	35 ft. 0 in.
	67 ft. 0 in.

The porous limestone of this section is not easily broken. Blocks of a large size may be obtained, and the unexplored beds, if found sufficiently compact, will prove valuable for quarry purposes, as well as for "burning." This deposit shows much false bedding, and dips to the south at an angle of twenty degrees.

At Thomas' quarry, in the pool of Peoria mill dam, fine square blocks of stone are quarried at the water's edge, below the cherty division of the silico magnesia division. This is the best stone seen in the county, but being at or below the ordinary water line, it will be difficult, if not impracticable, to prove its value.

Still higher on the Mississinewa, near Brouillette's, a quarry was opened, and stone obtained for pilaster coping for the Catholic Church at Peru. The modest, neutral tint of this stone contrasts well with the ruddy brick wall, and promises to weather well. This bed will justify its development, as it is very similar to the Delphos stone brought from Ohio.

MILLS AND MANUFACTURES.

The Wabash, Eel, and Mississinewa rivers, flow with a rapid current and offer a large amount of valuable water power, which is only partially utilized. Here is a large field for enterprise that should be made available.

The manufactories of Peru are in a flourishing condition, and, as I am informed, at the same time remunerative.

The Peru Woolen Mills, H. E. & C. F. Sterne, proprietors, is an extensive factory. It is described as a "six set" mill, with twenty-eight looms, and gives employment to one hundred hands. They make jeans, cassimeres, and cloths, to which have been awarded the highest premiums, in competition with the best manufacturers.

Gardner, Blish & Co. make "split" baskets out of oak, ash, and elm trees. They employ ninety hands at the factory, and ten or more engaged in outside work. Their wares meet a ready market, a sure proof of excellence.

The Howe Sewing Machine Company have a branch manufactory at this place. Nine hundred machines are made daily, or an equivalent amount of material prepared. They employ 450 operatives in this work. To this may be added three founderies, four wagon and carriage shops, with grist, saw, and planing mills, with capacity equal to the local demand. Timber is sufficiently abundant to supply all these establishments with material for work, with a large surplus to invite many additional manufacturers of wooden articles. The Peru Flax Mill and Bagging Factory, another new enterprise, consumes the ripe straw after the seed is threshed; employs eighty operatives. Their stock and manufactured articles often amounts in value to more than \$20,000.

Gravel, the best road material, is plenty along all the rivers which traverse Miami county, some of which has already been used in making gravel roads.

WABASH COUNTY.

Wabash county is traversed by the same rivers, in the same direction, and in general outline is almost a counterpart to Miami county, just described. The rock exposures are beds equivalent to those seen in that county, but extending to a lower division of hydraulic limestone and sandstone. Although the rocks are equivalent beds, they are changed in character. The upper or porous limestone is more silicious, but exhibits the same remarkable system of

false bedding, so often wrongly referred to as an upheaval or subsidence of the earth's crust. The gray limestone, seen at Logansport and at a few localities in Miami county, first becomes laminated, then cherty, while at Wabash it is thin bedded, and furnishes an unlimited amount of the best of paving stones. The silico magnesian beds of Logansport part with the greater portion of the calcareous matter at Peru, becoming argillaceous, while in Wabash county this bed is characteristically argillaceous, and in appearance very similar to the hydraulic stone at Louisville and other points.

GENERAL SECTION.

Soil and drift.....	5 to 90 ft.
Porous lime rock used for burning, and containing Niagara fossils.....	0 to 40 ft.
Paving, stones equivalent to the gray sandstone in Cass county, containing large <i>Cephalopods</i> of the genus <i>Or-</i> <i>thoceras</i> , <i>Cyrtoceras</i> , <i>Trochoceras</i> and Crinoid stems.....	8 ft.
Thick bedded argillaceous limestone, sometimes compact and highly mag- nesian.....	0 to 20 ft.
Hydraulic limestone and 'mud stones'...	10 to 50 ft.
188 ft.	

The porous lime rock presents the same general characteristics noticed in Carroll and Miami counties, and although somewhat silicious, yet the lower strata of this deposit will offer stone equal to that used in the other counties for burning. Lime was formerly burned at several localities, and an attempt was made at a quarry in the northern part of Wabash, the county town, but failed because of using the impure upper beds. At many of these localities, the enterprise was successful, and abandoned only when it was found that common kilns could not compete with the more economical patent ever-burning kilns. The product was of

good quality, and met a ready market. Opposite Wabash, on the south side of the river, J. Hildebrand & Co. have two common kilns with a capacity for each of seven hundred and fifty bushels a week. These kilns were in active and profitable operation, supplying the local market. Good stone for burning was noticed near LaGros, Hanging Rock and at several other localities besides the first mentioned.

The third bed of the general section is next in order. This bed of paving stone crowns the higher hills along the river at Wabash and was found underlying all the adjacent table lands, when not eroded, and is generally about eight feet thick, composed of a hard, pure, gray limestone, sheeted down in layers from two to four inches thick, of almost unlimited extent, separated by thin partings of clay.

This deposit is a great source of income to the citizens of this county. Although but a few acres have been quarried, about one hundred car and boat loads of this stone are yearly shipped to neighboring towns and cities to pave the sidewalks, etc. For this purpose I have not seen its equal, and the universal use which it obtains indicates that the quarries will equal, if not exceed in value, mines of any mineral in the State. The profit on the stone from a single acre is often estimated above \$12,000. At a few localities, the paving stone is interrupted or replaced by heavy bedded lime stone, but at Wabash it rests directly on the hydraulic sandstones; this is an exception to the general rule, although not unfrequently the case in the southern part of the city.

The paving stone bed is rich in large Cephalopoda, etc., of the Niagara formation, and of the following genera represented by from two to three species each, but with exterior so worn as to require the experience of a specialist for determination, viz.: *Cyrtoceras*, 3 species; *Trochoceras*, 3 species; *Orthoceras*, 2 species; the interior of the latter shell is often incrustated with *cornulites* differing but little from the common *Serpulae* of the coal measures.

Below these paving stones, and sometimes interchanging, occurs a deposit of thick bedded quarry stone, varying from 0 to 20 feet. Sometimes, however, it is found thrown down

from its legitimate position by the intercolation of the clay sandstones.

This quarry stone has been extensively worked by Major Stearns Fisher, on land now owned by Allen Craft. The product was shipped by canal and used for building locks and piers for bridges and aqueducts, as also for other private and corporation needs. The quarry bed is twelve feet deep, with strata from one to one and a half feet thick. In the shaly partings, between these strata, many *Fucoides* were seen.

On land belonging to Hon. J. H. Pettit, four miles west of Wabash, five quarries have been opened. One of them was being vigorously worked. The product is loaded directly from the quarry grounds on canal boats and shipped to Fort Wayne, Lafayette and intermediate points. The stone is readily quarried in shapely blocks, and meets with ready sale for foundations and hammered masonry. The survey is indebted to the proprietor for fine specimens of *Orthoceras*, *Cyrtoceras*, and *Calymene Blumenbachii* var. *Niagarensis*.

Returning to town we noticed on T. Craft's farm, two miles west of Wabash, a giant boulder—a pudding stone composed of irregular and angular lumps of granite, gneiss, sienite, etc., etc.—fifteen feet long, twelve feet wide and five feet high above the surface. This is the largest boulder I have seen in the State, and shows the wonderful transporting power of the iceberg flow which brought this mass from the north shore of Lake Superior. Other trap and conglomerate boulders were seen near by.

This rock might well command the attention of any people. No wonder that the simple children of the forest looked with wonder at this traveled stone, in their traditions a relic of the battle of the gods, and esteemed it a holy votive altar, on which their offerings of wampum, tobacco, etc., were left to appease the angry divinity.

Another boulder, near the county line east of La Gros, was revered by our savage predecessors as a holy stone, where offerings might be made efficaciously to avert dan-

ger from poisonous snakes, and was known as the altar of the great ruler of the serpents.

At Beck's quarry, two miles west of Wabash, about 1846, Robert Helm experimented with the hydraulic limestone there found. He burned, ground and sold a quantity. Generally, this lime when used without directions, proved a failure; but in all cases where mixed with a proper proportion of well slaked caustic lime, it proved a perfect cement. Mr. G. L. Dart, of Peru, used this cement in making a cistern. Eleven years afterwards he had occasion to remove this cistern, and found the walls in the best possible condition. The cement, as he reports, was harder than common bricks.

Experiments have been made with stone from equivalent beds obtained a short distance east of Wabash and from the bluffs of Treaty creek, with varying results. A few products of the trials hardened well under water, as I am informed by Dr. Ford, but generally I may say that the material examined by me was too argillaceous, and contained too small a proportion of lime. This difficulty may be easily remedied, as beds of stone, suitable for burning are abundant, and the property wanting may be cheaply added. In a commercial point of view this deficiency would be no detriment, as lime is a common and cheap product the world over, and may be added more cheaply, when used, than at the original place of shipment.

Full experiment will be necessary to first definitely fix the exact proportion of lime to be added. This experiment ought to be conducted under the charge of some patient citizen at the public expense. The results ought to be the property of the county. By this means a bed of material found throughout the county would become a great source of income. The supply is unlimited, as may be seen in sections hereinafter given. I add the analysis, of the sample, made by Dr. Ford :

WABASH CEMENT.

	No. 1.	No. 2.
Silica	30	27
Carbonate of lime.....	40	42
Carbonate of magnesia.....	19	18
Alumina and iron.....	5	4
	94	91

This analysis was probably not made of an average specimen, as the results of analysis made by Professor Cox shows the per centage of lime to be less than five per cent., while the per centage of alumina is much larger.

The following section, taken at Wabash, and including lime exposures in that vicinity, gives a general view, as the rocks vary much at short distances :

SECTION AT WABASH.

Soil and drift.....	16 ft.
Paving flags.....	8 ft.
Blue clay.....	2 to 4 ft.
Place of the porous limestone.....	0 to 15 ft.
Thin bedded sandstone.....	10 ft.
Blue hydraulic, argillo-magnesia lime- stone, weather buff to brown.....	30 ft.
Heavy bedded argillaceous lime rock, with a few large gasteropods like <i>Pleu-</i> <i>rotomaria</i> and <i>Fucoides</i> , to water line.	20 ft.
	103 ft.

The lower beds in the above section have been quarried for building the railway bridge in the east part of town. In appearance it is much like the Flat Rock stone, and the quality seems good. But from the large amount of clay contained, it is probable that some of this may disintegrate. Samples from this and similar beds throughout the county were secured for the State Cabinet, and complete analyses will be made as soon as office duties will admit.

At Small's mills, on Treaty creek occurs an anticlinal

axis, (fig. by R. Owen, Geology of Indiana, 1860,) with the superimposed limestones bedded down upon the ridge, and dipping at a high angle to the north and to the south. The line of strike is nearly from east to west, varying a few degrees to the northeast. This ridge is marked by a line of high land or sharp hills traversing the county for miles parallel with the Wabash river, and crossing that stream, as I am informed by Dr. Ford, near the line dividing this from Miami county. Mr. Small presented some fine hexagonal and prismoid masses of calc spar, with a specimen of *Cyathophyllum rugosum*, from a small Devonian outcrop at the top of the hill.

At Wilson's bluff, four miles east of Wabash, is a bed of hydraulic argillite fifteen feet thick. This place offers good facilities for shipping by canal or railway. A similar bed of equal thickness was visited on Chappelle creek in the northern part of La Gros. The specimen had the appearance of good cement stone. The analysis hereafter to be given of the specimen secured, will show the chemical constituents.

Near the mouth of the Salamonina and near its confluence with the Wabash is a cluster of sharp, conical mounds, 100 feet or more in height, formed by the erosive action of the rivers. One is acutely pointed and sugar-loaf in shape. Another, not over 200 feet in diameter at the base, and has one side rudely torn away by the Wabash which flows at its foot, is known as the hanging rock. This is a favorite picnic ground. Lovers still meet here and climb the same pathway to felicity "that their fathers trod."

SECTION AT HANGING ROCK.

Compact porous limestone irregularly bedded, and dipping N. W.

at 45°.....	60 to 25 ft. 0 in.
<i>Spherezochus</i> and <i>Calymene</i>	3 ft. 0 in.
Cherty argillite.....	10 to 60 ft. 0 in.

Horizontal clay stones.....	8 ft. 0 in.
Choice blue limestone to river bank	5 ft. 0 in.
	101 ft. 0 in.

A flat space, some forty feet square at the summit, affords room for a festal spread, and commands a broad outlook over the river and valley below.

The Mississinewa traverses the south part of the county from east to west. It is here a mill stream, highly valued as such. The rapid fall offers many valuable locations for mills. In early times, before the day of railways and other means of transportation, this stream was the highway of commerce. The people of Delaware county, at the eastern border of the State, I am informed, at the time of spring floods, would, by the Mississinewa, the Wabash, the Ohio, and the Mississippi, find a long, tortuous way, to New Orleans. A voyage of months, but then the only outlet for the cheaper products of their farms.

On Phil Davis' farm, one mile northeast of Somerset, this stream is confined by a precipitous wall of stone, sometimes over-hanging, or by the current cut in rounded buttresses and alcoves. The upper strata here consist of flaggy limestone in thin layers, filled with partings of chert from one to four inches thick, while on an adjoining farm the same bed is sufficiently pure and has been burned for lime. A thin stratum corresponds to the "fire stone" found at Logansport, which on exposure to the weather shows a peculiar greenish tint, perhaps due to the presence of silicate of lime. In partings between the thick flags were seen fossils of the following genera: *Zygospira*, *Orthoceras*, *Cyrtoceras*, *Trochoceras*, *Pentamerus* and *Athyris*.

The following section was taken on Davis' farm, half a mile above the lower dam at Somerset, viz.:

SECTION ON DAVIS' FARM NEAR SOMERSET.

Soil.....	1 to 4 ft.
Flaggy limestone.....	10 to 5 ft.

Heavy bedded sandstone.....	4 ft.
Clay parting.....	2 to 1 ft.
Argillaceous (hydraulic) sandstone.....	16 ft.
Blue bands and concretions highly argillaceous, to river.....	10 ft.
	40 ft.

On the farm of A. S. & W. Ross, half a mile west from Somerset, is a deposit of ferruginous earth (formerly bog iron ore) apparently from two to three feet thick, and covering an area of four acres. It is a tolerably pure oxide of iron. Roasted and ground as it is, or mixed with clays to vary the color, this earth might be utilized to manufacture the ochreous paints so universally used. The spring by which this mineral was placed here, flows out ten feet below, still highly charged with iron in solution, and may justify attention for medicinal purposes.

Good quarry stone is found for several miles, descending the Missisniewa, some of which has been hauled by wagons to Grant county, for the public buildings at Marion.

In generalizing we can say that, besides a fertile soil and a generous supply of water power, nature has endowed Wabash county with a boundless wealth of superior flag stones, good common stone, and an unlimited deposit of cement which needs only persistent effort to make it available.

HOWARD COUNTY.

Howard adjoins Miami county on the south. The surface is level, with scarcely perceptible undulation, and presents characteristically the undisturbed level of the bowlder drift. The soil was originally a rich black muck, since changed by drainage and sunshine into a light loam of great fertility. Good houses, substantial improvements, and well filled barns indicate satisfactory crops and a prosperous and energetic people.

Timber of the best quality is abundant, almost a drug,

for the supply is greater than the demand, and much is wastefully destroyed to make room for more remunerative cereal productions. The annual shipment of lumber from the county amounts to more than 10,000,000 feet. Of this, 6,000,000 feet is black walnut boards, bringing forty dollars per 1,000 feet. The balance comprises ash, oak and poplar lumber.

From the level character of the surface and the spongy nature of the soil, indifferent, if not impassable roads was one of the hardships with which the pioneer had to struggle; since, gravel and stoned roads have been built east, west and south from Kokomo. Gravel beds of small extent are found along the low bluffs of Wild Cat creek, and the flaggy limestones found at Kokomo are largely used for macadamizing, with the best results.

The rock exposures seen at Kokomo reach from the base of the Devonian black slate, down to and including a thin stratum containing silurian fossils, the principal exposures being Devonian. A well bored near the county seat gives the following section, and shows the hydraulic beds noted in Wabash county, well developed beneath the surface here:

BORE AT KOKOMO.

Soil	5 ft. 0 in.
Hard limestone, Devonian.....	50 ft. 0 in.
Gray limestone.....	30 ft. 0 in.
White silicious limestone, (here a strong current of water).....	50 ft. 0 in.
Blue mudstones, hydraulic limestone and clay shales.....	690 ft. 0 in.
	825 ft. 0 in.

Small quantities of petroleum came up with the sand pump at several points in this well, and there was a considerable discharge of gas.

This well was closed with earth. The detritus brought up by boring, after exposure to the weather for six years,

indicated a large preponderance of aluminous material passed by the auger in boring.

On the farm of G. F. Gleeson, four miles southwest from town, is an interesting gas well, in the drift clay, which probably terminates at or near a stratum of Delphi black slate (Genessee slate).

GLEESON'S WELL.

Soil.....	2 ft.
Yellow clay.....	14 ft.
Sand and gravel.....	3 ft.
Blue clay, boulder drift.....	36 ft.

55 ft.

At the bottom of this well a strong flow of water was found, which rose in the well to within six feet of the surface. With it comes a considerable discharge of carburetted gas, which continuously bubbles up through the water. It burns with a bright, clear blaze. Mr. Gleeson proposes to use this gas for household, culinary, and illuminating purposes, for which there is believed to be an abundance. The water has a slight infusion of petroleum. A number of chalybeate springs, on the same farm, are not affected by drouth, and also discharge illuminating gas. Notwithstanding these "signs of oil," I can say, after a careful examination of the oil bearing rocks on a long range above and below this horizon, that the probabilities against a paying oil well are great.

Near the fair grounds, two miles southwest from Kokomo, the Wild Cat runs over a solid floor of rock. In the channel are seen successive concretions derived by erosion from the lower member of the black slate noted in Carroll, Jasper, and White counties. On the north bank is a wonderful spring, welling up from a fissure in the solid rock, which pierces to an unknown but great depth below. The supply of water is not varied by drouth or wet weather. Gas bubbles up with the water, and a small quantity of petroleum may be detected. A shaly stone at the water's edge

is saturated with petroleum, and burns with a flame equal to the best Cannel coal. A good bed of gravel, just below the fair ground, was visited. Here choice material for making roads is found in abundance, and is used by the city and gravel road authorities.

Near the road leading to town, A. Bernard burns a flaggy limestone, for the local market. Lime of good quality is produced. At the city quarry and at Detenbough's, stone is quarried for lime burning, foundations, and road-making. At the latter, a good article of lime is produced in quantities, and a shale bed near the west line is so completely saturated with petroleum, as to invite experiments with it as an engine fuel.

SECTION AT DETENBOUGH'S.

Soil with debris, from the black (Genessee) slate.....	10 to 2 ft. 0 in.
Rough limestone with an obscure <i>Orthoceras</i> , <i>Chonetes setigera</i> , <i>Productus subalatus</i> , <i>Lucina</i> <i>proavia</i> , <i>Spirifer</i> , <i>Athyris</i> , and <i>Hemipronites</i> ?.....	2 ft. 6 in.
Flaggy limestone with bands and partings of chert, but some- times pure.....	5 ft. 0 in.
Slate saturated with and bedded in petroleum.....	1 ft. 6 in.
Silico-calcareous rock : some thick bedded	8 ft. 0 in.
	19 ft. 0 in.

The minerals of Howard county are not extensive. Enterprise has made a good use of nature's offering. Thankfully an energetic people have utilized these, their beds of gravel and stone, and may proudly boast that, in spite of nature's miserly gifts, they have built longer and better roads, than their neighbors who are more favorably situated.

Kokomo, the county seat, is situated at the intersection of the railways traversing the county, and is the terminus of five gravel roads. As a consequence, this young city presents a prosperous air of thrift. The court house is a handsome and costly structure. Howard College edifice is fully up with the times, while substantial and comfortable private buildings are common.

THANKS.

In conclusion, acknowledgements are due to the following gentlemen for information and guidance:

R. S. Dwiggin, Wm. Thompson, and the editorial fraternity at Rensselaer; Father Stephens, at San Pierre; Dr. Bushnell, at Monticello; Dr. Beck, Cartwright & Co., Hubbard & Co., and others, at Delphi; Wm. Miller, Maj. Dunn, D. Keepert, W. Wright, Dr. Bringhurst and S. J. Penrose, Logansport; E. H. Shirk, G. L. Dart and J. T. Hinton, Peru; A. P. Ferry, J. Mackey, Dr. Ford and S. Fisher, Wabash; A. B. Walker, T. C. Phillips and A. F. Armstrong, Kokomo.

Thomas Nelson, James H. Rogers and William Jarvis, Commissioners of Parke county, at their March term, 1872, ordered the necessary appropriation from the County Treasury to effect a geological survey of the county under the direction of the State Geologist. Professor B. C. Hobbs, LL. D., was chosen his Assistant for that work and the following is his detailed report with accompanying map :

PROFESSOR E. T. COX:

State Geologist :

I herewith submit my report of Geological Survey of Parke County:

Some matters of general interest, not strictly geological, have been introduced as desirable information for the general reader and are, therefore, within the instructions of the Statute.

With thanks for many kind favors,

I am, with regard, truly,

B. C. HOBBS.

Bloomington, Ind., Dec. 15, 1872.

REPORT
OF
GEOLOGICAL SURVEY OF PARKE COUNTY.

BY PROF. B. C. HOBBS, LL. D.

TOPOGRAPHY.

Parke county is bounded on the north by Fountain county, on the east by Montgomery and Putnam; on the south by Clay and Vigo, and on the west by the Wabash River, which separates it from Vermillion county.

It embraces the townships 14, 15, 16 and 17 north, and ranges 6, 7 and 8, and the eastern sections of range 9.

Rockville, the county seat, is in latitude 39 degrees and 40 minutes, and it is about 10 degrees west longitude from Washington City. The county contains an area of about 480 square miles.

Its general drainage is to the southwest. The Wabash, along its western margin, receives an unusual amount of tributaries from this county. But few counties in the State are as well watered. Its principal streams are the Big and the Little Raccoon, Sugar creek, Wabash and Mill creek, and Coal creek enters it in the extreme northwest. These streams all flow into the Wabash. The tributaries of Big Raccoon are chiefly from the north, and are Leatherwood, Rock run, Little Raccoon and Green creek. Little Raccoon receives Williams and Sand creek. Sugar creek

receives Rush creek, Roaring creek and Sugar Mill creek. The latter receives Green creek.

The Wabash has cut its channel down through the surface strata about two hundred and fifty feet, and its tributaries afford the geologist in many places, especially where the sand stone is not friable by exposure to the weather, an excellent opportunity to discover the thickness and character of its coal, clay and stone. The upper Big Raccoon, Sugar creek, Roaring creek and Sugar Mill creek wind in many places through deep gorges, and their banks afford the lover of nature much pleasure and admiration by their bold and massive cliffs and romantic rock houses. Turkey run, the Pinnacle, the Devil's Den, etc., are highly attractive places. When these wild and beautiful streams are made accessible by railroads, they will be found in many respects superior to any other rural scenery in the State.

The streams of Parke county generally widen their valleys as they approach their confluence. The Big and the Little Raccoon have for many miles a valley breadth of near one mile. Their valleys contain precipitated alluvium from the rich soils of the table lands, and are unsurpassed in fertility. The Wabash valley in like manner extends from one to two miles eastward. The forests have, to a great extent, been removed from these "*river bottoms*," and they are annually covered by contiguous maize fields, which often present an unbroken continuity of waving grain for miles on either side.

The surface of the table lands of the county are generally gently undulating. There are but few *sloughs* or *ponds*, and but a comparatively small portion of the county so precipitous that it can not be cultivated.

GEOLOGY.

CENOZOIC GEOLOGY.

The carboniferous strata of Parke county are covered by drift. This drift generally consists of red clay, sand and

gravel as a surface deposit. The red clay often gives place to a dark carbonized soil analagous to that of the upland prairie. In the flat beech land it is generally a pale tenacious clay, well adapted to grass and but little inferior in utility, with proper cultivation, to the river bottoms for corn and it is superior for wheat. These clays are so well combined with sand that the soils of Parke county easily pulverize and are every way desirable for cultivation. In many places, sand and gravel deposits are found showing that the rush of waters that brought them was not uniform in its movements nor in its deposits. These sands and gravel banks are interstratified. Coarse gravel, coarse sand and fine sand give place to each other often without regard to any law of superposition, and often sand deposits show ripple marks giving evidence of a lake which moved its sands by waves as well as currents.

The sand and gravel banks are most abundant along and in the bluffs and valleys near the Wabash, but are often found throughout the county.

A sandy soil prevails along and between the two Racons from Bridgton to Rosedale and along the southwest border of the county. Deep sandy ridges and valleys prevail in the northwest part of the county between Sugar creek and Cole creek. The indications favor the presumption that the movements of the waters depositing the drift varied in direction and velocity, and that the material was brought at different periods and from localities remote from each other.

Under this surface drift is a deposit of blue clay which is general throughout the county, except where cut through by river channels. This blue clay is from three or four to forty feet thick or more. When wells are dug through it, unless walled, it will cave in, in rectangular prism shaped blocks.

The waters which brought the blue clay from whatever country must have had something to do with the glacial action which cut or crushed a way through the coal and sandstone deposits, since it contains almost every variety of

material. Wood, sandstone, limestone and granite pebbles, gravel and sand of various degrees of fineness, broken fragments of coal, everything remote or near has been gathered up and borne along in the general movement of the waters or ice flow by which it was deposited.

A stratum of sand or gravel is generally found under the blue clay. When wells are dug down to it, an abundance of good, unfailing water is usually found, which will rise several feet above the bottom of the well.

Large pieces of timber are often found buried deeply in these clays; and I am reliably informed that in the northeast part of the county a well digger found what appeared to be the corner of a building. The timbers found bear strong resemblance to the fiber of the cedar and pine. In a few places mastodon teeth and fragments of bones and tusks have been found. No doubt if the pioneer citizens of the county were organized into an antiquarian association, many objects and facts of interest could be gleaned from them which would be of material value to the scientist, the geologist, and the antiquarian.

There are other topics intimately associated with this department of my Report which I prefer to include in what I may say on Soils and Timbers.

PALEOZOIC GEOLOGY.

The stratified rocks of Parke county belong to Paleozoic time. It exposes almost, if not fully, a complete series of the regularly recognized coal seams found in the State. Many of these seams exist only in the southwest part of the county, in the highlands of Wabash and Florida townships. Four, if not five, coal seams crop out west of Rockville, Catlin, and Rosedale.

The following exhibit is made out from an exposure in a valley entering the Big Raccoon at Mecca, on land owned by Lowry and Batman, which affords bold, nude walls nearly all the way from its first depression from the table lands to the river bank, and cutting the strata to a depth of about one hundred and fifty feet. East of Rock-

village the thickness and succession of the stratification is inferential, no positive data being at command to determine it. It is taken from exposures north and south of a line east of Rockville. The strata west of Rockville can be pretty accurately determined by the exposures on Big Raccoon, Leatherwood, and Rock Run or Iron Creek :

GENERAL SECTION OF THE ROCKS IN THE MIDDLE OF
PARKE COUNTY

Made from outcrops along the line running east and west through Rockville from the Wabash river to Putnam county, commencing with the surface drift, in a ravine near Mecca, which cuts through the strata to a depth of near 150 feet, and in which the rocks are well exposed. This exposure is on land owned by Lowry and Batman, in sections 14 and 15, township 15, range 8 :

- | | |
|---|--------------|
| No. 1. DRIFT—Red clay, blue clay and gravel | 30 to 60 ft. |
| No. 2. COAL—Opened, not worked. The roof is not determined. The cropping indicates good coal..... | 4 ft. |
| No. 3 SANDSTONE—Massive, excellent quality
The Clinton Iron Furnaces were made of it.
The best stone in the piers of the canal aqueduct at Armiesburg were obtained here.
It resists well the action of both fire and weather. Its color is cream-yellow or a flea-bitten fawn-skin. Portions of it are a rich brown. It quarries to any desirable size and shape..... | 40 ft. |
| No. 4. BLUE CLAY—With nodules of iron ore.
The ore is not abundant..... | 15 ft. |
| No. 5. COAL—A double seam. Each stratum 1 foot, separated by a stratum of blue clay of from one to six inches..... | 2 ft. |
| No. 6. FIRE CLAY—With kidney iron ore.
Ore under as well as through it..... | 4 ft. |
| No. 7. GRAY SANDSTONE..... | 2 to 3 ft. |

No. 8. BLUE CLAY—With a small quantity of kidney ore.....	20 ft.
No. 9. COAL—Good, bituminous.....	3 ft.
No. 10. FIRE CLAY.....	3 ft.
No. 11. SANDSTONE—A good building stone. Gray, yellow and brown with specks of oxide of iron.....	4 ft.
No. 12. BITUMINOUS SHALE. —With thin seams of coal.....	4 ft.
No. 13. SANDSTONE—Blue and gray and in thin strata.....	2 ft.
No. 14. BLUE CLAY—With iron ore more abundant than in seams above.....	5 ft.
No. 15. LIMESTONE—In layers from three to eight inches.....	2 ft.
No. 16. COAL—Associated with this seam are irregular shaped sextaria nodules of pyritous iron ore, generally small, but here four to five feet long, and two to three feet across. This coal indicates identity with the cropping at Armiesburg bridge. Inferior quality. I take it to be identical with the seam at Woodward's and Butler's mines, and at R. Outland's or Leatherwood. At each of these places it affords a superior, rich, bituminous coal much prized by smiths.....	2 to 4 ft.
No. 17. SANDSTONE—Underlaid by a ferruginous claystone and in places runs into fire clay	8 to 15 ft.
No. 18. COAL—Rich, bituminous. Often contains too much sulphur. It shows above low water mark at the bridge at Armiesburg. I take it, and the seam above, to be identical with coal at Clinton Locks, and at Steele's mines, at Rosedale and at Roseville, in "the general section of the coals" given by Professor Cox in his report for 1870, marked L.....	4 to 6 ft.
No. 19. BLUE CLAY—Thickness not known...	20 to 25 ft.

No. 20. BLACK LIMESTONE—Sand creek, upper seam K.....	4 ft.
No. 21. COAL—Semi-block.....	4 ft.
No. 22. SHALE.....	25 ft.
No. 23. BLOCK COAL—Crops out below K at Sand creek, and is mined by Nye & Co. I, or main block.....	3 ft.
No. 24. FIRE CLAY.....	10 ft.
No. 25. SOAPSTONE.....	6 ft.
No. 26. SANDSTONE—Yellow.....	20 ft.
No. 27. BLUE SANDSTONE.....	2 ft.
No. 28. GRAY SANDSTONE.....	5 ft.
No. 29. SANDSTONE—Massive, millstone grit. At Mansfield it is a beautiful reddish-brown.	40 ft.
No. 30. DARK SHALE.....	6 ft.
No. 31. COAL.....	1 ft.
No. 32. FIRE CLAY.....	0 ft.
No. 33. FERRUGINOUS LIMESTONE—On Big Raccoon.....	7 ft.
No. 34. LIMESTONE—Subcarboniferous. This formation extends eastward through Putnam county .....	.....

The last ten strata are inferential, being taken in part from borings in different localities.

There is much variation in the thickness and character of the rocks in different places. The section here presented will, however, afford a general idea of the successive deposits which make up the surface material of the county to a depth of perhaps 250 feet measured from the table land east of the Wabash river. Eight seams of coal, most of which are workable, measuring in the aggregate more than 20 feet, here lie buried, waiting for the miner.

GENERAL OBSERVATIONS UPON THE COAL, IRON ORE AND SANDSTONE IN THE PORTIONS OF THE COUNTY EXAMINED.

I commenced my reconnoissance in Florida township, at

Clinton Locks. Three coal seams crop out at this place, which I take to be N, L and I of Prof. Cox's corrected section of coal measures, page 168, Report of 1870.

The upper and middle seams were worked many years ago when the Wabash and Erie canal afforded transportation. Much of the supply of Terre Haute and above was from this place. The upper seam measures four feet; the middle one five feet. The lower seam has recently been found in the bed of a stream on the land owned by J. M. Wilson. The upper and middle are separated by about twenty-five feet of bituminous clay slate, and the middle and lower by about twenty feet of shale. The middle vein has afforded the main source of supply. Since the canal has ceased to afford transportation, but little mining has been done here. It is a rich caking coal, but has too much sulphur for smelting purposes.

The lower seam had not been mined sufficiently to determine its thickness. It indicated a good block coal.

These veins dip to the east at the rate of forty feet to the mile, and to the north at the rate of twenty feet, showing a reverse order to the ordinary dip, which is about twenty degrees south of west, and at an average of about twenty feet to the mile.

The table land above is about seventy-five feet above the general level west of the Wabash, as ascertained by observations of J. T. Campbell, former county surveyor, who happened to be engaged in a survey of that locality about the time of my visit.

The bed of the middle coal seam is about five feet below the level of Montezuma, as shown by a railroad survey running near it. The outcrops were not sufficiently clear to enable me to ascertain the greatest depression of the seam northward. It evidently rises and reappears at Butler's mines, near the mouth of Leatherwood, and at Mecca, in Wabash township.

MECCA AND RACCOON VALLEY.

Crossing the ridge to Mecca in Raccoon valley, I found

the interesting exhibit of the first seventeen strata, presented in "The General Section of the Rocks in the Middle of Parke county."

This ravine affords an interesting variety of material both for the miner and the scientist. Seam number 3 is represented by forty feet of sandstone. It shows but ten or fifteen feet here, but half a mile south it is about forty feet thick and a very superior building stone. It can be quarried to a desirable size and shape and will yield well to the hammer and chisel.

In many places down this valley kidney iron ore is abundant, and several coal seams may be advantageously worked. The home demand has hitherto been so small on account of its inaccessibility, that but little mining has been done.

Corresponding coal seams and sandstone appear on the west side of the Raccoon on the lands of William Hixon, and at other points in that vicinity.

Ascending the Raccoon valley half a mile south of Mecca, I found kidney ore abundant and much of it sufficiently rich to invite the attention of iron manufacturers. Coal is occasionally seen cropping out in the ravines, but the exposures were not such as to enable me to determine their thickness, roofing or quality. For several miles above Mecca there are no bold projecting cliffs along the stream until we reach the vicinity of Roseville.

In section 5, on lands owned by Allen Lewis and John W. Mark, two veins of coal appear, each about three feet, also an excellent quality of yellow sandstone. The railroad which will soon be completed from Carbon to Chicago via Danville, Ill., will offer an incentive to the owners to develop it more fully. These coals I take to be L and M, and correspond with those at Roseville and Rosedale.

About one mile northwest of Roseville the same two veins are found on land owned by W. Evans and G. W. Bement. The lower seam is five feet six inches. I was unable to procure fair samples of it, but it is represented to be a good coal, burning to a brown ash with but little clinker. The

earth had caved in upon the mine when I visited it, so that I was unable to inspect it.

I consider this lower seam identical with the coal east of Catlin, at Beal's mines, and marked I. It crops out at the water's edge at Roseville. It will probably be a good block coal, from indications where opened, and from its thickness ($4\frac{1}{2}$ feet) will no doubt prove of much value when the railroad down the Raccoon valley is completed.

At Roseville is a fine exhibition of carboniferous sand stone, or millstone grit.

At Roseville is a fine exposure of carboniferous or conglomerate sandstone. It has the appearance of a ridge of stone, which in the carboniferous period extended above the waters in which the coal plants grew, and on either side of it the coal and shale seams are fitted to its sides without a variation in their level. North of the stream it presents a bold, rugged cliff, from which has been taken much valuable building stone. On its crest is a beautifully white, friable sandstone, which finds its way to Terre Haute and Indianapolis for the manufacture of glass. Portions of it are damaged by peroxide of iron, which changes it into a rich red color, and destroys its market value for glass. I shall not be surprised to hear of this stone being sought by Chicago and Indianapolis. It is a soft stone and readily quarried, but hardens on exposure, and is every way desirable as a superior building material.

The Big Raccoon, a mile or two above this place, has evidently once in a time had a channel by Rosedale southward, down a wet, low prairie which passes east of Terre Haute and enters the Wabash some miles below the city. By one of those wonderful disturbances among the rocks, for which our earth has been remarkable, a channel has been opened for it northward to Armiesburg, across a high ridge composed of stratified rocks, where it enters the Wabash about twenty miles above its former confluence.

Perhaps about the same time, and while great changes were going on in Parke county, for nature's dynamic forces have distorted and disturbed it much, especially in Florida,

Wabash, Reserve, and Penn townships, Leatherwood, which evidently once ran from Bloomingdale across through the present valley of Rock Run, found a new channel opened for it through the highlands west of Joel Reynold's place, across the lands now owned by J. Parker, H. Little, P. Pearson, and P. Mitchell, and it re-unites with the Rocky Run valley near its intersection with the plank road leading from Rockville to Montezuma. The old bed of Raccoon is now occupied by the Terre Haute and Crawfordsville Railroad, and its present valley has invited a branch of the Chicago, Danville and Vincennes road through it in quest of the block coals in southern Parke and Clay counties.

Coal I, described above, passed out of view under the stream above Roseville, and K and L crop out along the hillside above to Rosedale, where Gen. G. K. Steele has had entrances which have yielded a large supply for market by the Evansville and Crawfordsville Railroad. The seam here works about five feet, but is not sufficiently free from sulphur to be desirable for smelting ores. It is a good coal for steam and grates, and corresponds to the coal at Clinton Lock. It has not, however, been convenient for him to continue his mining operations for the past two years, and when I visited the place no coal could be seen which would indicate its character. These seams show very favorably above Roseville, where they have been successfully mined for many years.

Opposite Roseville, above and below the ridge of millstone grit, or conglomerate sandstone above described. The same coal makes a good showing on the lands of Evans and Hawkins. The demand has not hitherto been sufficiently great to develop its qualities. When avenues to the markets are opened, there will be found sleeping in these hills material wealth that will reward the industry of many generations.

Adjacent to this coal is a superior massive sandstone. It is of a cream yellow and brown color. It yields well to the hammer and chisel, and can be readily procured of any desirable dimensions. It extends for some distance up the

valley of Rock Run, making majestic, overhanging moss-covered cliffs. I shall not be surprised to see, some day, a switch from the Raccoon Valley Railroad span that stream to reach this waiting and inexhaustible supply of building stone.

Passing up the valley of Rock Run about two miles, these rugged, romantic, precipitous banks, begin to mellow into soil covered hills, and at section 3, township 14, range 8, on the lands owned by Daniels and Bailey, the seams L and K again make their appearance, rising as we go northward more rapidly than the stream. Its roofing is a silicious and clayey, and in many places ferruginous limestone, bearing marks of identity with the coal on S. Woodard's place in Rock Run valley, and at Butler's mines.

Kidney iron ore is very abundant along this valley. It would afford a good supply for admixture with the Superior ore.

A seam of fire clay about eight or ten feet thick separates the two coal seams. The upper coal is about two feet thick and the lower, as nearly as I could ascertain, is about four feet.

Two miles north, in Wabash township, on H. H. Anderson's land, section 27, township 15, range 8, the upper seam measures twenty inches, and the lower seam is in the bottom of the stream and the thickness is not ascertained. It is considered very desirable by smiths who have used it. ~~can~~ In section 14, I found a very abundant supply of iron ore imbedded in blue clay. The stratum is about thirty feet thick. The ore is not so rich as abundant. It would not, probably pay to work alone. Leaving this point we find but few exposures that would attract attention until we reach the table lands.

RACCOON TOWNSHIP.

Crossing Little Raccoon near its mouth and passing up the north side of Big Raccoon, a more delightful valley is rarely seen. A rich, gently undulating, sandy soil fills the space between these rivers for some two or three miles, when

hills and stratified rocks are found on the left and a continuous expanse of valley extends to Mansfield. Its breadth is generally about one mile.

In sections 29 and 30, there are croppings of coal but little attention has been given them. In section 7, on Jackman's land, two seams appear. The upper one has a roofing of carboniferous limestone containing *Encrinite* stems, *Bellerophon carbonarius*, *Chonetes mesoloba*, *Athyris*, etc., corresponding with the coal on S. R. Beal's land, on the south side of Little Raccoon.

The upper seam is about four feet thick and yields an excellent coal. It is bituminous but a semi-block. It may be found to answer for smelting purposes.

Under this are strata of fire clay and shale, at the base of which is a stratum of encrinite limestone and a second seam of coal underlying it in bed of stream, the thickness of which was not determined. This locality is very inviting to the miner and manufacturer, and when approached by the North and South Railroad will yield a good and satisfactory supply for market.

In the branch, about half a mile northwest, is found a very interesting exhibition of Amygdaloid or Trappe formation of iron ore. It consists of horizontal strata of cubical, wedge shaped, and quadrilateral prism shaped blocks and bars of ore, generally about one inch in diameter. Some of these bars are a foot long. The bottom of the branch is spanned by this stratum of ore.

In sections 3, 4, 5 and 8, on both sides of the Little Raccoon, on land owned by Samuel R. Beal, Calvin Gilkerson and others, there is an abundant show of excellent coal. It varies in thickness from four to five feet six inches. The N. & S. Railroad survey passes through this region. Two veins, I and K, are found, evidently corresponding to Jackman's and Sand creek coals. They have been but little mined south of Raccoon, on account of the small demand near by and the difficulty of reaching the market. Along the railroad survey, passing over the hill towards Bridgton, the same seams are found, promising a good yield on the

north side of Big Raccoon. In these several localities, a good article of kidney iron ore is found in varied abundance, with copious deposits of fire clay.

In sections 34, 35 and 36, in the southeast part of the county, coal I, a good block coal, is mined. Much of these lands is owned or leased by companies for mining purposes. The N. & S. Railroad survey passes through this locality. The coal seen is mined in beds of streams or along their banks, and are covered with drift. Their proper roofing is not discoverable; their thickness is about four feet. A "lead mine" legend is remembered with interest in this vicinity. The Indians, in an early day, are said to have found an abundant supply of lead on or near section 36, which they melted and ran into bullets. They kept the locality a profound secret. The penalty for showing it to the white man, was cutting out the tongue. When they were preparing to leave for the far west, much importunity was used and rewards offered for its discovery, but in vain; they claimed that the Great Spirit gave it to the Indian and increased the supply as fast as he used it, and if he let the white man have it he would use it all up and the Great Spirit would not furnish a supply for *him*. There has been much searching for the hidden treasure, but no one has been able to find it.

JACKSON TOWNSHIP.

There are few favorable exposures of coal in this township. The southwest corner comes within the general coal field, and in section 32, I am told, a five feet seam of coal is found. I was unable to reach it. A good showing of coal was discovered on Clear creek, in section 22, on the land of J. N. Bell, which, when worked, may be found desirable. On Mr. Peech's place, in section 14, is found an eleven-feet seam of rich bituminous shale, which, when worked sufficiently deep, assumes a solid, compact form and breaks with a cannel coal fracture. It burns well, but leaves a slaty ash. It has been mined in the bottom of the stream, but at the time of my visit none but weathered specimens could be seen.

In this vicinity may also be found fire clay of fine texture resembling "slip clay." I understand its qualities have not been fully tested. A good showing of fire clay is also found half a mile north, on Bullion's land. A similar showing is found on the farm of Calvin Pruitt, in section 4.

No doubt, by boring and surface examination, good coal seams may yet be found in the western part of this county.

The limestone makes its appearance in the bottom of Big Raccoon, just above where it crosses the line between Jackson and Union townships. Near this locality, in Union township, in section 33, a ten-inch seam of coal is found under a dark shale. From its locality, I infer that it is the lowest of the coal seams of the county.

Iron ore is abundant in many localities in this township, especially on Clear creek.

By far the most desirable mineral in this township is its sandstone. In the vicinity of Mansfield is found in very great abundance a beautiful massive, solid, durable, brownish-red sandstone. It can be quarried in blocks of any desirable size or thickness. It is of a uniform color, and dresses to a good finish. I think it has no superior.

This township is generally hilly and the banks of many streams are continuous walls of carboniferous or conglomerate sandstone. It is most generally a yellowish-brown. It assumes all kinds of fantastic faces—cliffs, "rock houses," honey comb and barnacle surface, and very generally an antique moss-covered exposure, showing how perfectly it can resist alike the decomposing power of frost and air. This township would afford ample business for a railroad to Indianapolis or Chicago in the transportation of its superior and inexhaustible building material. I shall speak of its superior timber in another place.

UNION TOWNSHIP.

But little coal is found in this township. I have mentioned a ten-inch seam in section 32, under a dark bituminous shale. The same coal appears in section 22, on J.

Martin's place. A seam is also found in section 27. The thickness I could not learn. The same nine-inch seam crops out in a branch, half a mile south of Hollandsburg, on J. O. Stout's land, but 25 or 30 feet under it is a fine display of limestone in the bottom of the branch. In section 3, on S. Burke's place, about two and a half miles north of the latter place, is a very fine cropping of a three-foot seam of good block coal. Limestone, about 15 or 20 feet, under it, is in bottom of the branch. The same seam shows equally well half a mile north, on Carver's place.

About half a mile south of Bellmore is a fine display of iron ore, on Miller's place. All the way up Raccoon valley, massive, yellow, conglomerate sandstone is seen, and limestone is usually present in the bottoms of the valleys. These limestone exposures correspond with the Putnam county formation, and assure us that we here reach the downward limit of the coal deposits.

ADAMS TOWNSHIP.

In section 25 and 26, on J. Beard's and J. Neven's land, is found a very good coal. I was unable to reach it. Its qualities were spoken of in very high terms by different and disinterested gentlemen. As nearly as I could learn, these coals measure about three feet. In sections 32 and 33 are found Beal's mines, north of Little Raccoon, and marked I upon the map. This coal measures about five feet. The North and South Railroad passes over it. It was not worked when I visited it. It is under the drift, and but a few feet below the surface in the Raccoon bottoms. An old entrance had been abandoned, and a new one more convenient commenced. When the North and South Railroad shall be finished, I expect an active business will be conducted in this locality in mining and in iron manufacture, lying as it does contiguous to an unfailing supply of water in Little Raccoon.

As we advance up Williams creek, along the line of the North and South Railroad to Rockville, iron and coal ore

are frequently exposed. A. Pickard is just opening an excellent seam in section 17. The same seam has furnished Rockville for some time past with a good article of semi-block coal from Walker's place, one mile above. The latter has too much sulphur for smelting purposes, but answers well for grates and steam. It is marked K upon the map, and I take it to be the upper seam of Sand creek. It is mined in a branch, and I was unable to ascertain the character of its roofing. It measures about four feet. About half a mile east of Rockville, it is found in the bed of Williams creek, and again in section 5. In sections 26 and 35 this coal is found on Beard's land. The sample shown me was very superior. I have no doubt but that it underlies the entire township. Wood is too abundant to warrant the expense of mining by a shaft, and the miner must wait until some avenue can be had to bear it to a distant market.

In Little Raccoon valley, east of Rockville, is found a very superior quarry of carboniferous sandstone. It quarries into any desirable blocks. It has a very sharp grit, and is excellent for grindstones. In some places it is beautifully white, in others red, brown and yellow. It resists the action of frost and air well, and is a very desirable building stone.

WASHINGTON TOWNSHIP.

I shall only speak here of that portion of the township which is drained by Little Raccoon. In sections 34, 33, 27 28 and 21, along the valley of Sand creek, are found two coal seams, marked on the map K and I. The upper is roofed by a carboniferous limestone. Under it is fire clay and shale, and about twenty-five feet under it is a three-feet seam of block coal. The seam K is variable in quality. It generally yields a superior bituminous semi-block, but in some places it has too much sulphur for smelting purposes. The block coal seam has not yet been mined sufficiently to test its qualities. It bids fair, however, to take a favorable place in the market. Very extensive operations are here

conducted by Nye & Company, and the Parke County Coal Company, by means of the transportation offered by the Logansport, Crawfordsville and Southwestern Railroad. A large number of mines are worked for neighborhood supply, in croppings along the hillsides. An analysis of these coals will appear elsewhere in a tabulated form.

In sections 14, 23 and 24, northwest of Judson Station on the Logansport, Crawfordsville and Southwestern Railroad, is a continuation of the Sand creek coal seams. Their paleontological characters are the same. They are here accompanied by an abundance of good kidney iron ore on the lands of A. Buchanan, Esq., where also is found an interesting display of band ore. The upper seam measures about five feet, and is pronounced by Professor Foster, of Chicago, the richest ore in the Indiana coal fields. (See table of Analysis.) It lies there waiting for a switch and the miner. Excellent sandstone is found in the hills in this locality. It is generally gray and yellow. I found here some interesting specimens of *Sigillaria*. Limestone makes its appearance in the bottom of Raccoon, a little below Judson.

GREEN TOWNSHIP.

Coal makes its appearance in the southwest part of this township, in section 31, on lands owned by J. Marks. It is a very flattering outcrop of a five-foot seam of block coal. In a valley half a mile south, two seams are found; the upper about three feet, and the lower two feet. One of the surveys of the Indiana and Illinois Central Railroad passes over these coals. Timber is so abundant, and the demand so light from lack of transportation, that no important attention has been given to it. Immense treasures are here silently sleeping, where a busy population will one day be found, and forge fires will probably send up their flames for many future generations.

I have already noticed J. Carver's coal in section 34. An outcrop of a twenty-inch coal appears also on J. Strong's place in section 19, and two miles north, on D.

Burris' land, which is mined in a stream by removing the soil cover. It does not promise well either for thickness or quality.

A good brown and bright red sandstone is found on J. Strong's land, in section 17, which has been worked considerably the past summer to supply a demand in Clinton county. It does not, so far as tested, show enough uniformity of color to make it very desirable as a building stone. It answers well for foundations. Limestone is found in the northeast portion of this township, showing that we have passed below the coal seams. A good quality of lime is made from this stone. Carboniferous sandstone is found abundant in the bluffs along the streams generally through the township.

Reserve, Penn, Liberty, Sugar Creek and Howard townships not being conformable to the Congressional townships and very irregular in their boundaries, I can complete the description of my reconnoissance best by ascending the streams, rather than by townships.

Leatherwood enters the Big Raccoon one mile above Armiesburg. Just above its confluence, section 7, township 15, range 8, are found five coal seams four of which have been worked. The upper one, M, corresponds with the upper seam at S. Woodard's mines in section 4, and measures twenty inches. It is separated from the seam below by a space of eight feet—three feet of fire clay, four of a greenish argillaceous shale underlaid by a black pyritiferous slate containing fish teeth, *Petrodus occidentalis*, spines and scales, *Cardinia fragilis* and *Aviculopecten rectilutaria*. The second seam which is now most worked is four and a half feet and is marked on the map, L. It yields a good caking coal and an eighteen-inch stratum of block coal. It corresponds to the main seam at Rosedale and Roseville. It also contains bands of iron pyrites and a pyritiferous clay parting. The third seam, K, measures about four and a half feet, and corresponds to the upper seam at Jackman's mines in Raccoon township. Under this seam is a five feet stratum of fire clay, four feet

of argillaceous shales, a soft schistose sandstone ten feet, shales twenty-one feet. Under this is the fourth coal seam overlaid by a thin seam of black slate. It measures about eight inches. It is underlaid by

"Gray shale.....	8 ft.	0 in.
Black sheety slate, with fossil shells of which <i>Cardinia fragilis</i> , <i>Ortho-</i> <i>ceras Rushensis</i> , can be recognized	3 ft.	0 in.
Coal.....	0 ft.	6 in.
Gray shale.....	8 ft.	0 in.
Black pyritiferous shale, passing into hard gray fossiliferous limestone, containing <i>Productus cora</i> , <i>P. Cos-</i> <i>tatus</i> , <i>P. Wabashensis</i> , <i>Spirifer cam-</i> <i>eratus</i> , <i>Bellerophon carbonarius</i> , <i>B. Montfortianus</i> , <i>Cyathaxonia pro-</i> <i>lifera</i> , <i>Orthoceras Rushensis</i> , <i>Cho-</i> <i>netes mesoloba</i> , and large stems of Crinoids"		18 in.

(See Prof. Cox's Report for 1869.)

This black pyritiferous shale is often suspected to be plumbago. It will mark paper well, and can be readily cut into pencils, but will burn easily, leaving a slaty ash. This seam is but a few inches above the surface of Leatherwood.

During the past year, about forty thousand bushels of coal have been taken from these coal seams to supply the demand in Montezuma and other places in the vicinity.

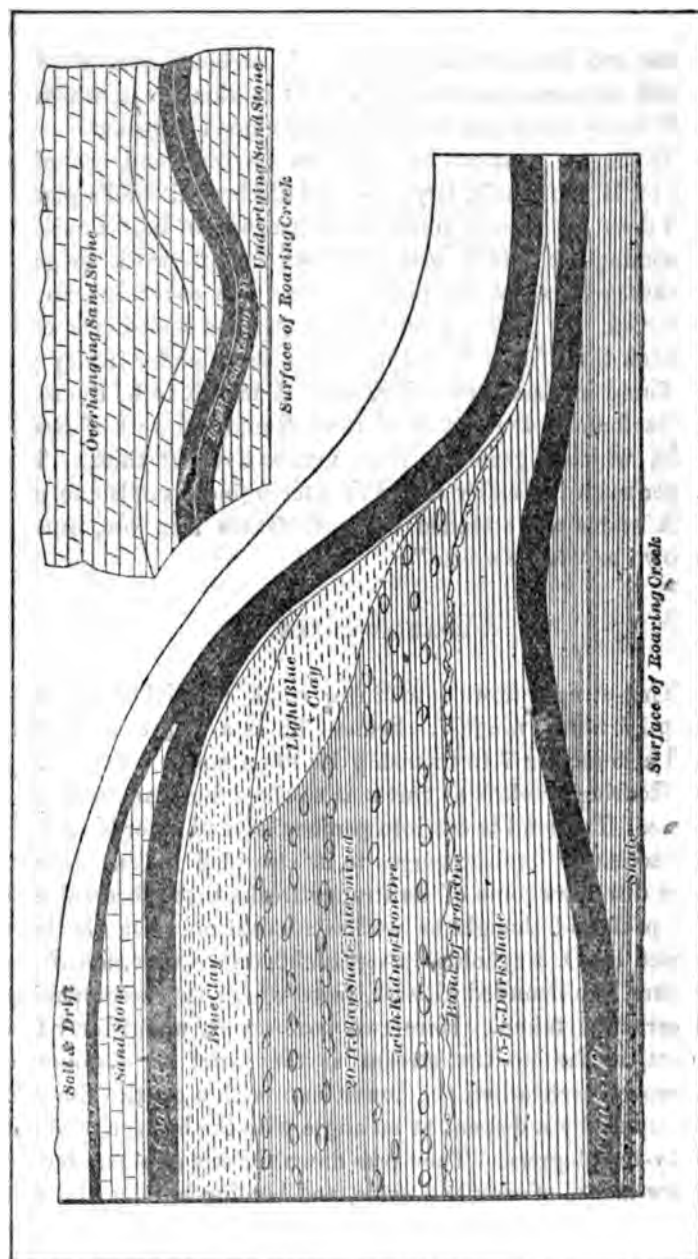
In section 4, on Solomon Woodard's place, L and M crop out in a ravine, where they are mined to good advantage. The upper seam measures about twenty inches, and is separated from the seam below by eight feet of fire clay. The lower seam, L, measures here from four to six feet. A *basin* and *horse-back* occur in this mine. In the latter, at the highest point, it measures four feet; in the *basin* it measures six feet. It is a bituminous coal, and gives good satisfaction in the market.

On the opposite side of the valley of Rocky Run, these seams are inferior in quality. A carboniferous slate is found accompanying the lower vein at this place, which is sufficiently solid and durable to make good flagging.

The upper mine can be traced up Leatherwood, cropping out on R. Outland's, Bryant's, and Perley Mitchell's places, and does not vanish until it reaches within half a mile of Bloomingdale. It is generally too thin to work to good advantage, except in places where the covering can be removed. It is of a good quality and is a semi-block coal. I think that if search was made the seam under it may yet be found in Leatherwood valley. I take it to be the same as that found in the bottom of Rock Run, southwest of Rockville, which is generally from four to five feet thick. The upper seam is usually roofed by a ferruginous sandstone, and both seams are attended by pyritiferous iron ore, usually known as "*turtle stones*."

ROARING CREEK.

This stream flows into Sugar creek in section 30, township 17 north, range 7. Section 32 is a rich coal district, and also section 7 in township 16, same range. The valley of Roaring creek is as tortuous as the mind can well conceive. The land is cut into peninsulas, and affords abundant access by its deep gorges to its stratified rocks. Nature here discovers some of its strange freaks that afford subjects for profound thought as well as admiration. On the land owned by D. Reynolds, in section 32, on the west side of the stream, is a denuded hillside, from which the accompanying diagram is taken. Here two coal seams, about forty feet apart, as far up the stream as they can be discovered, approach each other, the lower one with a gentle rise and the upper by a descent at an angle with the horizon of about forty-five degrees. They pass down the stream separated by a few inches of clay and shale, and become hid by the soil and vegetation. About one-eighth of a mile below, on the opposite side of the stream, these two seams are exposed in



the mines of D. Reynolds, affording an excellent supply of block coal, which would no doubt find a ready demand in any market whenever transportation can be had. The two seams will mine about thirty inches each, and being separated by but about eight inches of clay shale, and having an excellent sandstone roof, the miner will have a clearance of about six feet.

A short distance north of this mine is a like exposure, in Captain Durman's mines, where very flattering invitation is given to the miner. Tracing the gorge in which this mine occurs to its terminus in Roaring creek, these same coal seams are found still near each other; one above and the other below the surface of the stream, and yielding an excellent coal. Passing down to a narrow passage of the stream at the Rubottom mill seat between the opposite sandstone cliffs, on the right, is the cropping, evidently of the same coal seams of very inferior quality, abounding with so copious a supply of copperas that the *early settlers* used to resort to it as a mordant for their dyes. The united seams are here but about two feet. On the southwest and opposite bank can be seen, much below the level of the exposure above described, an evident extension of these seams closely and tortuously embedded between two sandstones, the lower of which is much the most friable. Passing up Roaring creek a fair show of coal occurs on the land owned by T. Nelson, in the same section. In this locality is an excellent sandstone, which serves a good purpose for foundations. On Bundy's land a little farther east, the upper seam described is worked very successfully. It is here a block coal, and measures about four feet. I think these will be found identical with Buchanan's and Mark's. This locality will some day, when reached by rail, afford abundant inducements for the miner.

SUGAR CREEK.

I was unable to inspect the exposures of coal on Sugar creek, immediately above and below the mouth of Rush creek. Hess' mine is represented to afford good coal. I

did not learn the thickness of the seam. It and the one south of the creek below are perhaps the same as a two-foot seam on the canal, on Wright's place, in section 6, township 16, range 8, roofed by an encrinite limestone. On Josiah Campbell's place, a two and a three-foot seam crop out—the same that will be described in Coke Oven Hollow—and roofed by a two or three-foot seam of limestone. I was unable to find an exposure that would indicate its quality or the paleontological character of the limestone roof. It has not been mined recently and the debris had covered it.

About half way up the hillside, south of the Feeder Dam, is an exposure of coal which has not yet completed the transition from the organic to the inorganic form. It presents a beautiful and conclusive evidence of the vegetable origin of coal—the fern and flag stems and leaves being so perfect that many of them can be separated and then show their forms as perfectly as if they were the relics of a preceding year. Other portions have decomposed, leaving their residuum of carbon in mass, with fossil indications less distinct.

“Coke Oven Hollow” is named from the business conducted in it by Wm. G. Coffin about thirty-five years ago. He had a foundry at “Mount Etna” near by, and procured his pig iron from Cincinnati, Hanging Rock and Pittsburg. It was transported by wagons from Cincinnati, and in order to have loading economically both ways, he mined and coked coal in this Hollow, which reaches Sugar creek just below the Feeder Dam, and would either make sale of it in Indianapolis, Richmond or Cincinnati. This is a forcible illustration of the disadvantages under which industry was placed at that day in contrast with the present, and of the discovery which has since been made of the adaptation of our block coals to the uses of the forge without the waste and loss of coking.

Four coal seams crop out in this valley.

The upper seam is a composition of clay, shale and bitumen, and has a soapy feel. It has a strong resemblance to *black lead*, but when exposed to heat the bitumen will burn

with a blaze until consumed, leaving a fire clay shale as a residuum. It will mark freely like plumbago. It measures about 15 inches. It has been used as a black pigment in oil painting and makes a neat finish. It will also, very probably, serve a good purpose for lubrication. Above this coal is a very desirable sandstone. It has very sharp grit and much of it is so white and clear that I have no doubt it will serve a good purpose for the manufacture of glass. About fifteen or twenty feet below this seam, and under a soapy clay, is found a two-feet coal seam. It is covered by a carbonized limestone. Further down the valley are two superior coal seams; the upper one measures two feet. It is covered by a sandstone roof and has been mined along its outcrop, for smith purposes, for many years, and is much valued. It is a rich caking coal. About 15 or 20 feet of shale separates it from a seam of about 3 feet near the bottom of the ravine which yielded the "Coke Oven" supply before referred to. This seam would be extensively mined if it were not too inaccessible. These seams crop out farther east on S. Jordan's place, and are being mined for the market.

FIRE CLAY AND "SLIP GLAY."

Near the head of Coke Oven Hollow, on R. A. Coffin's land, by some of nature's primitive forces, the strata have been cut through from north to south, and a channel of some 200 yards breadth has been made to a depth of 40 feet or more, the bottom having never been reached. R. A. Coffin's stoneware manufactory stands here. This chasm is filled with an excellent fire clay and it has, in different localities, five different varieties. The upper portion is of variegated color and the proprietor assures me that from it can be made a good article of white ware. Farther down, he is satisfied that the clay will make a fire brick that can not be excelled. He has tested it by exposure to intense heat with brick of best reputation in the market.

Another clay burns to a beautiful reddish-purple and the ware is beautifully smooth.

This fire clay has so good a reputation in the market that he has shipped, by the canal, as much as 619 tons, in one year, to Toledo, Maumee, Delphi and Attica. The supply at this place appears to be inexhaustible. His pottery establishment occupies the place made vacant by mining.

Near by, on S. Jordan's place, a very good clay is also found and on H. Little's place, half a mile west of Bloomingdale.

The glazing of the stonewares are made by a surface finish of "slip clay," which is a very fine fire clay of such chemical composition that it will melt at a less heat than the clay of which the body of the ware is made. This surface of *slip clay* thus becomes a *flux* and glazes the surface of the ware.

Formerly, potters in this county sent to Lucas county, Ohio, to Maumee City, to Seneca Falls and Albany, New York; to Independence, north of Attica, and to other distant places for supplies, but of latter times a superior article has been found in our own county west of Wildman's nursery, on I. Woodard's place, to which the craft in adjoining counties resort for supplies. It is found also below the falls of Wabash Mill Creek and on Josiah Campbell's place below Feeder Dam. I do not know what judgment has been reached by experiment with the latter. I think it probable that it may be also found on Peache's land in Jackson township. Fire clays extend so nearly all over the county that the supply may be regarded as inexhaustible for all time, and the best varieties can be found.

A few hundred yards above Feeder Dam is a show, above the stream of millstone grit, or conglomerate sandstone. It rises above the stream and sinks beneath it at various points all the way up to the Narrows, where it rises into the uplands and gives place below to the limestone deposit. About one mile above the dam is a fine display of iron ore on a forty-acre lot owned by Milligan of Waveland. This is mainly in kidney nodules in a bed of shale,

but a heavy band or bed of ore is found near the bottom of the stratum. The miner is especially invited to an examination of this spot. In the ravines above is a beautiful display of excellent building sandstone in massive cliffs waiting to be borne to some distant market where it would be of priceless value. Above it, on Ephlin's place, is a nice outcropping of a four-foot coal seam—but, having no solid roofing to protect it from the debris above it, has not been successfully mined. When the demand will justify, a shaft may reach it from the table lands.

A short distance above Milligan's Iron Bank is a legendary spot. In "early times," the Indians, it is said, found a supply of lead in the bed of Sugar creek at this place. They would wade into the stream and feel the ore with their feet and thus procure their supplies. They were not disposed to show the pale faces the spot, and soon after they had left their hunting grounds, the construction of the Wabash and Erie Canal demanded a feeder dam across the stream below and the search for lead in its bottom was made hopeless. The canal dam having gone into decay the stream may in time be reduced to its former level and the lead hunters may yet hope for success.

Between this point and Rockport is another very gratifying exposure of coal. At Starkey's mines, on the south side, much very good bituminous coal has been mined from a two-foot seam. On the north side of the stream, in section 35, on Weaver's and Noland's lands, are found two good coal seams, bedded on fire clay and with sandstone roof. The upper seam is about two feet, and the lower one three feet to three feet five inches.

This coal is about half a mile below the crossing of Sugar creek by the New Albany and Salem Railroad, and can be made very accessible by switching.

On H. Weaver's land is a very excellent chalybeate spring in a deep and romantic valley, which can not fail in time to be a cool summer resort for the invalid, when travel to it shall be made easy.

As we approach Rockport, the conglomerate sandstone

makes a rapid uprising, and the coal seams melt into a friable combination of bitumen, sand and slate.

At Rockport are found on both sides of Sugar creek a high and massive projecting sandstone, which will serve an excellent purpose as abutments for the North and South Railroad bridge that is expected to cross at this place. Near the line of the road is an excellent sandstone, as fine as any I have seen in the county, except the Mansfield stone. It will no doubt some day find its way to Chicago. But little coal is found between this place and Roaring creek. Square Rock Branch, however, is a locality of some interest. It is on Robert Wright's place, about one mile above Rockport. A two-foot seam of black limestone is here exposed, which has very regular lines of fracture. It has over it and under it a black clay which has become incorporated with it so as to give it color. It is quarried in square blocks, from 6 to 18 inches in breadth, and from 6 inches to 1 foot in thickness. It will admit of a good polish, but is not sufficiently indestructible by exposure to the weather to render it valuable for foundations, or for furniture tops. A seam of iron ore is under it, and is also fractured with great regularity into cubical blocks of different sizes. It rests on a fine, carbonized clay, in a stratum measuring about six inches. It has been found to make a good polish for shoe blacking, and will serve a good purpose for lubrication. The experiment has been made to wagon this iron ore to Terre Haute, but the cost of transportation was found too great.

On section 30, township 17, range 7, a very desirable coal crops out on the north side of Sugar Creek, on H. Russell's land. It mines 3 feet 8 inches, and is a rich, semi-block coal. It appears clear of sulphur, has a sandstone roof, and its bed is fire-clay. This seam is found also on J. Moore's place, near the mouth of Mill creek, and just above his mill, in the bed of the stream. It measures about five feet. In the north bank of Mill creek, at this point, is a two-foot seam of coal, under a sandstone cliff. I think it probable that these two seams are the two seen at

Buchanan's, along Roaring creek, and on Mill and Green creeks above. At Moore's place they have not been sufficiently worked to learn their qualities. Some months ago, in time of a freshet, the waters from J. Moore's dam, cut through the coal underneath, and mined it out in large blocks.

In sections 3, 10, 14 and 15, can be found an exceedingly rich coal field. Two seams crop out on both sides of Mill creek. Near the county line, at J. Lawson's mines, the under coal seam measures from five to six feet, and is made up of three strata. The upper is block, the middle a seam of pyritiferous iron ore and cannel coal, and the lower bituminous coal. The amount of sulphur must greatly impair its value. This coal also, is remarkable for its minute septæ of calc spar. Much depends on the care of the miner in assorting this coal for the market.

About a quarter of a mile west is another exposure on G. Barker's land which makes a show of much better coal. It mines from four to five feet. It yielded a good article of block coal in the upper stratum of the seam, and the lower stratum is a rich bituminous coal. About two miles below, on G. Barker's land, a bank had recently been opened, which made a fine show of good block coal, apparently free from sulphur. I saw no indication of a difference in quality as in the mines above. In the bluffs east of Ward's Mills, (Russell's Mills,) two coal seams are found, but they were not sufficiently exposed to indicate their thickness or qualities. One mile and a half west, on Green creek, these coals again crop out. They make a good showing on Barker's and Ratliff's lands. At the former place, the principal mine is in the creek bottom and is mined six feet, the bottom has not been found on account of water. The upper three feet is an excellent block coal and the lower stratum is bituminous. This coal will probably be found as desirable as any coal in the State. In the bank about fifteen feet above, is a good showing of another coal seam. Both seams are roofed by limestone and are separated by shale. The upper seam is but partially exposed. No one appeared to know its thick-

ness. It is considered not less than five feet. These two seams evidently are under the North & South Railroad, from Sugar creek northward into Fountain county, and can be readily approached anywhere by shafts and switches. They are probably the same as the two mined on Coal creek, in Fountain county, which measure three feet three inches and three feet nine inches.

RUSH CREEK.

Along this stream, on C. Farner's land, a good showing of coal is seen, which supplies the smiths in the vicinity, also on Huxford's lands below, but its thickness could not be ascertained. A two-foot seam and a less one are found outcropping in various places along the canal from Sugar creek to Howard, covered by encrinite limestone. The coal seams, for some cause, become thinner as we approach the Wabash, or in other words, as we leave the circumference of the coal basin. I am inclined to favor Professor Cox's hypothesis, that it was only in shallow water that coal plants grew luxuriantly, and as the waters deepened the coal deposits were less abundant, and would at a sufficient depth entirely fail, hence one of the great irregularities of coal seams, and of their disappearance entirely in certain localities. It is probably for this reason the coal seams maintain their thickness with much uniformity from north to south along the outer rim of the coal basin and diminish in their measures as we follow them westwardly.

NARROWS OF SUGAR CREEK.

The scenery here is wild and picturesque. Heavy cliffs of beautifully white, yellow and cream colored conglomerate sandstones are found on both sides of the stream, and if reached by rail would afford a very desirable supply of stone for building as well as for glass manufacturing. An excellent laminated sandstone is also found here, that can be split into desirable thicknesses for flag stone. Half a

mile above, a *bastard sandstone* is quarried, which is a rare material for flagging. It is on H. Lipsie's land.

The white sandstone above referred to is on J. Lusk's land. The ledge is capped with it as at Roseville. It is a clear white stone with a sharp grit, and crushes easily, but completely resists when exposed to the disintegrating power of the weather.

The "*Narrows*" at this place is a narrow passage of the stream between two perpendicular walls of sandstone about thirty-two feet high and of fifty-five feet span. During high water, the stream rushes with a whirl through this deep gorge with tremendous force. A second and narrower channel is found some fifteen feet deep in the river bed, with offsets on either side, at the bottom of which, I am informed, is limestone.

NEWLIN, M'MURTRY'S AND CANNON'S COALS.

About one and a half miles above "*The Narrows*" is a valley of more than ordinary interest. It gives the following section of the rocks of that locality. It is an interesting fact that here the conglomerate sandstone again gives place to the regular coal and shale foundation; this section reaching down to the water surface without finding it. Near its entrance into Sugar creek, cannel coal is found a few feet below the surface, under the sediment of the stream and near its head. In Cannon and McMurtry's mines it occurs above the block coal, making about an eight or a twelve-inch seam. In the ledge of sandstone found along this valley, the *Lepidodendron* and *Sigillaria* fossils, some of which are seen quite large, instead of being petrified as is usually the case, are converted into cannel coal. Clumps of this fossil coal are seen all through the sandstone without any connection with or being a part of any regular seam, and showing perfect impressions of the bark of these coal plants. About half a mile east of this valley, on W. M. Newlin's land, was found two large blocks of cannel coal, containing about eight cubical feet each, detached from their original stratum,

which will no doubt be found near by. These blocks are now in the collection of the State Geologist at Indianapolis, and weigh 890 pounds. The sandstone in this locality is generally a rich fawn skin color, and answers an excellent purpose for foundations.

The section given commences perhaps fifty or seventy-five feet below the general land surface above.

SECTION OF THE ROCKS IN SECTIONS 25 AND 36, TOWNSHIP 17, RANGE 7.

No. 1. COAL—Semi-block, with a seam of cannel coal on top, varying from ten to twelve inches.....	4 ft.
No. 2. BLACK SHALE.....	20 ft.
No. 3. COAL—Quality not determined.....	1½ ft.
No. 4. IRON STONE—Regularly fractured.....	4 to 6 ft.
No. 5. DARK BITUMINOUS SHALE.....	15 ft.
No. 6. BAND OF IRON ORE.....	1 ft.
No. 7. SHALE and IRON ORE.....	4 ft.
No. 8. SANDSTONE—With cannel coal fossils..	30 ft.
No. 9. Band of Iron Ore.....	1 ft.
No. 10. COAL.....	1 ft.
No. 11. SHALE—With Iron Ore.....	40 ft.
No. 12. Sugar Creek.	

GENERAL INFERENCES.

Number of Coal Seams and their Character: Eight coal seams are discoverable in Parke county. The four upper seams appear to be confined to the southwest portion of the county, and to the high land between Rockville and the Wabash, extending as far north as the breaks of Sugar Creek.

Seams K, I, G, and F or A, are found generally through the county, except the northeast portions of Green and Howard townships. They generally diminish in thickness as we follow them westward, but increase in measure as we advance northward. Seams K and I, which are about three

and four feet in the southern portion of the county, measure, north of Sugar creek, five and six feet. K is a semi-block coal. It is well adapted to steam purposes. Sometimes it assumes a block like form when mined, but most generally breaks into cubical forms. Carbonate and sulphate of lime are often traceable in its joints, and sometimes sulphate of iron.

It will not resist the action of the weather equal to some other coals which impairs its value for extensive transportation unless protected. It has more than ordinary volatile matter, and yields a superabundance of smoke when burned. It is valued by blacksmiths on account of the hollow arch formed by agglutination in burning. Its lime and other mineral admixtures unite to form a flux and there results more or less clinker.

Since the Logansport, Crawfordsville and South Western Railroad has opened a way for the transportation of this coal, the corporations of Nye & Co. and the Parke County Coal Company have done an extensive mining business on Sand creek, and I find their coal ranks among the best in the Indianapolis market for locomotives, for general steam purposes, and for grates.

These coal seams are subject to much irregularity on account of the wave-like foundation of the conglomerate sandstone on which they rest, as at Roseville and Big Racoon above Feeder Dam at Rockport, and the "Narrows" along the valley of Sugar creek, coal being found often only in the intervening valleys and cut off by sand ridges which perhaps rose above the surface of the lake in which the coal plants grew.

Who knows but the Creator in his fourth day's work had a special design in giving us access to most invaluable building material through the same medium of transportation which would furnish fuel for the manufacturer and the forge-fire? I know of no locality which brings so many rich treasures into so close proximity.

I had hoped in this survey to be able to discover some reliable law of dip and level that would be a guide to the

miner and enable the land owner to make some probable estimate of what is buried beneath his soil, but the more I traced the variations in level and the uncertainty of even the existence of coal seams at any given locality, the more completely am I satisfied that such knowledge can only be determined by boring and by the shaft.

LIMESTONE, FIRE CLAY AND IRON ORE.

Limestone: This stone is found as a roofing for coal K generally over the county and often in connection with other strata. It is often sufficiently durable to serve for foundation stones and it will burn into a good article of lime.

Should this limestone not prove sufficiently pure for fluxing iron ores, a supply can be readily found of the best material on the eastern borders of the county.

Fire Clay: This valuable material is general and abundant, from a very fair or light color to a dark blue, and sometimes mottled with yellow and red, and from a gritless clay to a silicious admixture which furnish almost any variety of material for the manufacture of wares and the very best of fire brick.

Iron Ore: Banded and kidney ores are abundant throughout the county, and may be estimated to yield about 33 per cent. of iron. Very good clay ironstones are found on Mill, Roaring, Sand, and Little Raccoon creeks. Professor Foster has classified them under the following three heads:

I. *The Impure Carbonates of Iron*, including clay ironstones, in flattened spheroidal masses, and in bands more or less continuous, associated with argillaceous shales.

II. *The Brown Sesqui-Oxides, or Limonites*, intermixed with white potters' clay—a modification of No. I.

III. *The Silicious Oxides*, at or near the base of the heavy bedded sandstone, the result, no doubt, of permeating waters highly charged with protoxide of iron.

These ores indicate sufficient richness to justify smelting, whenever facilities can be had for cheap and ready transportation. Especially do they show that the county has all

the desirable ore for admixture with those of Missouri and Lake Superior, for smelting and manufacturing purposes.

Prof. Cox, and Prof. Foster of Chicago, have both given a favorable opinion in reference to the adaptation of the Parke county coals to the manufacture of iron. I can not discover any evidence of deterioration in the quality of the block coals as we advance from Brazil and Carbon to the northern extremity of the county, and shall expect the capitalists to find safe and profitable locations for smelting ores through its entire length, whenever railroad transportation shall prepare the way.

ANALYSIS OF COALS OF PARKE COUNTY.

Buchanan's Coal: Section 23, township 16, range 7. Specific gravity, 1,232; a cubic foot weighs 77 pounds.

Coke,	-	-	64.5	{	Ash, white,	-	-	-	2.0
				{	Fixed carbon,	-	-	-	62.5
Volatile matter,			35.5	{	Water,	-	-	-	4.5
				{	Gas,	-	-	-	31.0
100.0									
100.0									

Sand Creek, Nye & Co.: Sections 22, 27, 28, 34, township 16, range 7. A cubic foot weighs 77 pounds.

Coke,	-	-	58.5	{	Ash, white,	-	-	-	2.5
				{	Fixed carbon,	-	-	-	56.0
Volatile matter,			41.5	{	Water,	-	-	-	3.0
				{	Good, illuminating gas,	-	-	-	38.5
100.0									
100.0									

BORINGS.

At Bloomingdale:

Soil.....	5	ft.
Quicksand and gravel.....	10	ft.
Blue clay, hard pan.....	42	ft.
Sand rock, bastard ?.....	14	ft.
Slate.....	2	ft.
Coal, indicated.....	0	ft.
Fire clay.....	4	ft.
Black clay shale with sandstone.....	27	ft.
Gray slate.....	10	ft.
Block coal.....	3½	ft.
Potters' clay.....	0	ft.

One and one-half miles north of Bridgton, Charles Caldwell, borer:

Surface drift.....	12 ft.
Hard pan.....	3 ft.
Fire clay.....	10 ft.
Soapstone, sand rock and shale.....	4 ft.
Dark slate.....	3 ft.
Streak of burnt coal, sand rock, dark slate and shale.....	20½ ft.
Sandstone, yellow.....	5½ ft.
Sandstone, blue, with streaks of slate.....	2 ft.
Sandstone, gray.....	5 ft.
White limestone.....	3 in.

At Bridgton, north side in bottom of the stream, C. Caldwell, Borer. Crossing of North & South Railroad:

Drift.....	8 ft. 0 in.
Gray hardpan.....	5 ft. 0 in.
Block coal.....	2½ ft. 0 in.
Fire clay.....	0 ft. 6 in.
Block coal.....	2½ ft. 0 in.
Fire clay.....	10 ft. 0 in.
Slate.....	1 ft. 2 in.
Fire clay.....	1 ft. 0 in.
Sand rock, gray.....	1 ft. 0 in.

EXTENT AND VALUE OF THE PARKE COUNTY COALS.

There is an area of about three hundred square miles of workable coals in Parke county, which, I think, may be safely estimated to average a mining thickness of five feet. Each solid foot will weigh seventy pounds, which is one-tenth below the common estimate. Their measure will then be about one and a half billion tons, which, at thirty cents, their value in the mine, may be estimated at about \$440,000,000, or about fifty times the present estimate of the value of the taxables in the county. At three dollars per ton, their cost on the cars, their value will reach the enormous sum of near four and one-half billion dollars, and in the Chicago market twice that sum. This estimate will give us some faint idea of our material hidden wealth that is waiting for the laborer, of the value of the miner's labor, and of the work and expense incurred in transportation, and also of the vast inter-

est the county, State, and the country have in the development and reduction of our mineral resources, leaving our iron, clays and sandstones out of the estimate. It will also suggest the influence such masses of mineral wealth must have on the construction of railroads for their transportation.

THE CONTEMPLATED RAILROADS OF PARKE COUNTY.

It may be discovered that to reach all the varieties of coals in Parke county it is necessary to construct the road which is to bear them to market along their eastern outcrop, instead of across it, since these coals diminish in thickness and in value as we go westward.

The North and South Railroad has successfully found this line, and crossing the streams of the county at right angles it is favorably situated for sending lateral branches up and down the valleys to which coal, stone, lumber, every commodity, can find an easy approach. Other roads will find it convenient as a feeder along its entire line. When it shall be completed I can think of no road that can anticipate a more desirable business.

The Indiana and Illinois Central will pass over some of the best coals in the county and by sending a track down Big Raccoon to Mansfield, may reach the very desirable brown sandstones in that locality, and the good coals on Roaring creek can also be readily approached by switch. When these roads shall be made, they, with the Logansport, Crawfordsville and Southwestern Railroad, will cause Parke county to take an enviable rank among her sister counties in the business of mining and iron manufacture.

SOIL AND TIMBER.

Soil: The surface of Parke county is drift. It varies in different localities. It may be classified into five general divisions:

1. *Alluvium* or river bottoms.
2. Sandy soils.
3. Loamy uplands.
4. Red or yellow clay.
5. Wet or light clay.

These several soils having been brought from other regions by drift or glacial action and by the streams, they bear no relation to the rocks beneath them.

The alluvium in the "river bottoms" is charged with all the elements desirable to promote vegetable growth. Abounding in phosphates, the corn fields which skirt the Wabash and are found on both sides of many of our streams, varying from half a mile to a mile in breadth, are unsurpassed for luxuriant growth and for the abundance of their yield. These soils are washed from the uplands, and when the river bottoms are flooded, a new supply is deposited as sediment. They can by this means be kept in constant cultivation without other fertilization.

2. *Sandy Soils*: These are found in what is usually known as "second bottoms," or the level lands bordering the "river bottoms." They are generally beds of sand and gravel covered by a dark rich soil and are adapted to all kinds of edible grains, and are the most desirable lands for general culture. The drift soils generally contain a great variety of chemical elements and whether in uplands or lowlands are such as are well adapted to all kinds of agricultural productions.

In the western portion of the county lying north of Sugar creek, the upland is a continuous sand bed, presenting a rolling surface; also the southwestern portion of the county south of Rosedale, is, with the exception of the wet prairie previously referred to as the probable former channel of Big Raccoon, much of the same character.

Loamy Uplands: All the uplands of Parke county possess a sufficiency of sand to render them easily pulverized. They are not apt to bake or become cloddy, as is common with purer clays. There is in the upland soils but little uniformity, left as they have been by water currents or glacial action, or both. On the same farm, and on the same level, may be found a rich, black, deep prairie soil, while in an adjacent field will be a yellow or pale earth. Much of the upland surface of Parke county is of this rich, dark, loamy soil, and yields a harvest, in favorable seasons, that competes well with the bottom lands.

Red and Yellow Clays: These clays alternate with the dark loam, and retain well any fertilizing element. They are well adapted to clover and the small grains. This county has no superior for wheat. It rarely fails to give a desirable harvest, and has within the past few years produced a good crop, when in many other portions of the State wheat has failed. These lands yield very excellent corn, especially in the middle and eastern portions of the county, where the surface is more level and retains its *humus* by filtering its waters, rather than parting with them by rapid drainage.

Pale Clays: These clays are common in the flat uplands, and beech and white oak abound on it. It retains moisture well in dry seasons, and when treated generously by a rotation of crops, and turning into it occasionally a clover or blue-grass sod, it proves to be a very productive soil. Under drainage not only takes away the superabundance of water that is left on its surface because of its impervious nature, but induces a porosity which enables the roots of plants to obtain a supply of air as well as to penetrate to the moisture beneath in time of drouth. Some of these lands, which were once thought too poor to be purchased, are now found to make the most desirable farms. They also yield some of the best timber in the county.

Making a general average of all their good and less desirable qualities, including healthfulness, a good Providence has made an excellent average of His blessings in Parke county, and anywhere in it is a good place to live.

TIMBERS.

Parke county embraces in its forests nearly all the desirable timber trees of the State. Its flora embraces the varieties of the prairie as well as of the woodlands. The poplar, oak, walnut, ash, cherry, sycamore, hickory, maple, beech and elm are found in their several varieties for this latitude, and in some portions of the county attain a height, symmetry and diameter unsurpassed in the State.

FLORIDA TOWNSHIP.

The white and burr oak and the poplar are the leading timbers of this township. The walnut is found where the lumberman has not been. The canal on the west, the railroad on the east, and the prairie demand from Illinois, has depleted the timbers in this section of the county.

Liberty, Reserve, Wabash, Penn, Washington, Adams and Raccoon townships have some magnificent forests of excellent timbers, but the demand from Illinois, home consumption, and the railroad and canal have all been busy in seeking the best of them. In many less accessible places, some valuable oaks and poplars are still found.

JACKSON TOWNSHIP.

The deep valleys and numerous hills in this township have hitherto been obstructions to the lumberman, and preserved its fine forests in many places in their primeval beauty and grandeur. I have never seen more desirable poplars or oaks in any place. I measured one white oak at two and a half feet above the ground, and found it sixteen feet ten inches in circumference, and another was about eighteen feet. The poplar is of corresponding girth and very tall. Other timbers are proportionately large. When a railroad can find its way up the Big Raccoon valley, a very profitable business will grow up in this portion of the county in timber and stone.

Union and Howard townships are very analogous to Jackson township in every particular except in the amount of broken land. They have fine forests, and their remoteness from good transportation has prevented their abundant timber from being destroyed.

Green township is now traversed by the Logansport, Crawfordsville & Southwestern Railroad, and the abundance of sawed lumber along the line shows the activity that is at once given to the trade when easy transportation is found to the market.

Along the bluffs of Sugar creek and its tributaries, the

hemlock is seen, which gives a cheer to the winter scenery. Much of it is of desirable size for lumber.

The following classification will exhibit the character of our principal forest trees. I have not deemed it proper here to attempt a full exhibit of the flora of the county. The very excellent report of Prof. A. H. Young, of Hanover, on the flora of Jefferson county, in the Geological Report for 1870, will be found to be a general description of the flora of this region. Parke can add a few prairie flowers which are not found in the highlands of that county.

TREES COMMON TO PARKE COUNTY.

Ash, White or Gray, *Fraxinus americana*—very abundant.

Ash, Blue, *Fraxinus quadrangulata*—common.

Ash, Swamp, *Fraxinus platycarpa*—occasional on low lands.

Beech, *Fagus ferruginea*—very abundant.

Crab Apple, *Pyrus coronaria*—often found; not very abundant.

Buckeye, *Æsculus glabra*—very common in river bottoms, and in rich uplands.

Coffee Nut, *Gymnocladus canadensis*—occasionally found.

Cottowood, *Populus monilifera*—abundant along streams; occasional on the upland.

Dogwood, *Cornaceæ cornus*—very common.

Elm, Red or Slippery, *Ulmus fulva*—common.

Elm, White, *Ulmus americana*—common.

Elm, Hickory, *Ulmus racemosa*—common in low grounds.

Gum, Black, *Nyssa multiflora*—abundant.

Gum, Sweet, *Liquidambar styraciflua*—seen occasionally; rare.

Hackberry, *Celtis occidentalis*—frequent.

Hazel, *Corylus americana*—abundant in the south and west.

Haw, Red, *Cratægus æstivalis*—common.

Haw, Black, *Viburnum prunifolium*—occasional.

Hickory, Shellbark, *Carya alba*—abundant.

Hickory, Western Shellbark, *Carya sulcata*—abundant.

Hickory, Brown or Pignut, *Carya porcina*—frequent.

Hickory, Water, *Carya aquatica*—common along the streams. Excellent for ax-handles.

- Ironwood, or Hornbeam, *Ostrya virginica*—common.
 Honey-Locust, *Gleditschia triacanthos*—occasional.
 Linden, or Basswood, *Tilia americana*—common.
 Maple, Sugar or Rock, *Acer saccharinum*—very abundant.
 Maple, White or Silver, *Acer dasycarpum*—found along the streams.
 Maple, Swamp, *Acer rubrum*—very common.
 Mulberry, *Morus rubra*—common.
 Oak, White, *Quercus alba*,—large and very abundant.
 Oak, Burr, *Quercus macrocarpa*—large and abundant.
 Oak, Chinquapin, *Quercus prinoides*—common.
 Oak, Black Jack, *Quercus nigra*—occasional.
 Oak, Red, *Quercus rubra*—occasional.
 Oak, Pin, *Quercus palustris*—common.
 Pawpaw, *Annona triloba*—very common.
 Poplar, or Tulip Tree, *Lyriodendron tulipifera*—very abundant.
 Red Bud, *Cercis canadensis*—common.
 Spicewood, *Lindera benzoin*—common.
 Spruce, Hemlock, *Abies canadensis*—common on Sugar Creek and tributaries.
 Sycamore, *Platanus occidentalis*—very abundant along the streams; occasional on the upland.
 Walnut, Black, *Juglans nigra*—abundant.
 Walnut, White or Butternut, *Juglans cinerea*—common.
 Water Beech, *Carpinus americana*—common.
 Wild Cherry, *Prunus serotina*—common.
 Willow, *Salix cordata*—common along the streams.

GRAVEL.

Along the "Second Bottoms" of the Wabash, Sugar creek and the two Raccoons, beds of terrace gravel are found, and in the channels of all the streams, gravel and sand bars are numerous, and yield supplies for roads and other purposes in their vicinity. Very frequently deposits of drift gravel, are found along the bluffs in the uplands, of an excellent quality.

WATER POWER.

No county in the State, except Wayne, has so many and desirable mill streams as Parke. Sugar creek, the two Mill creeks and the two Raccoons, are excellent mill streams.

Many of their tributaries, in an earlier day, supplied power for both grist and saw mills, but during the past thirty years they have been gradually failing. The removal of forests, of the underbrush and of the abundant decomposing vegetation, which absorbed and retained the waters from rains, and facilities afforded for drainage by cultivated fields, together with the corresponding facility thus given to the action of the sun and air in the process of surface evaporation, all these causes are combined in the diminution of the currents of our streams. The ruins of saw and grist mills are now found along their valleys where was an active business thirty years ago.

The ingenuity of the age having brought the steam engine to a great degree of perfection and adapted it so completely to every desirable location that the necessity for water power has diminished with the diminution of supply.

There are still great manufacturing interests that must depend largely on a copious supply of water power, and when approached by rail, Sugar creek, Big and Little Raccoon and others of these streams will afford privileges rarely found.

At Mecca, on Big Raccoon, is a large woolen factory, flouring mill and saw mill owned by Lowry and Batman. Excellent flouring mills are also found at Bridgton and Mansfield on the same stream, at Rockport on Sugar creek, and at J. Moor's and C. Ward's on Mill creek.

The general supply of water through the county by spring and wells has been attended by a diminution corresponding to that of the streams. During the past few years wells very generally have required to be deepened, and many springs, which once were regarded as never-failing, have ceased to flow during summer.

The well digger rarely has to encounter stone in sinking for water. If it is not found above, or in the blue clay, he is very sure to meet an abundant supply under it. Water by wells is found in drift, or terrace sand and gravel. Springs often appear along the hillsides among the rocks, but most generally where the valley sinks below the drift.

ACKNOWLEDGMENTS.

I am under obligations to Thomas Nelson, James H. Rogers and William Jarvis, Commissioners, and to John H. Tate, Auditor of Parke county, for many favors. And for hospitalities and assistance in various ways in my field work, in—

Adams Township: Gen. G. K. Steele, Wm. H. Nye, J. Pickard, J. T. Campbell, and McMillon, Stark & Dooley.

Washington: A. Buchanan, Esq., and J. Strong.

Sugar Creek: J. Garrigus, J. Lusk, and J. Moore.

Liberty: J. Wright.

Reserve: S. Woodard, W. B. Morris.

Wabash: Wm. Hixon, Lowry & Batman, and J. Butler.

Florida: Jos. Wilson, J. Blaize, A. Lewis, and J. W. Mark.

Raccoon: Dr. Crooks and D. Kalley.

Jackson. Col. C. Johnson, C. Pruitt, G. W. Hansell, and W. Peach.

Union: L. C. Acker.

Green: R. W. Cooper.

Penn: H. Weaver, R. A. Coffin, Capt. Durman, J. Ephlin, H. Little, P. Mitchell, and S. Jordan.

Howard: W. M. Newlin.

Respectfully submitted,

BARNABAS C. HOBBS.

PROFESSOR E. T. COX,
State Geologist, Indianapolis, Ind.:

DEAR SIR—I have the honor to submit, herewith, my
Report on the Geology of Dearborn, Ohio and Switzerland
counties.

Yours truly,

ROBERT B. WARDER.

CLEVES, OHIO, Dec. 1, 1872.

G E O L O G Y

OF

Dearborn, Ohio and Switzerland Counties.

CHAPTER I. SURFACE FEATURES.

Dearborn, Ohio and Switzerland counties, all bordering on the Ohio river, present such similarity in structure and character that it is more appropriate to make a report of this district as a whole, than to describe each county separately.

This district extends forty-three miles from north to south, and twenty-one and a half miles from east to west. The area is as follows:

Dearborn county.....	186,311 acres,	291.11 square miles.
Ohio county.....	54,749 acres,	85.54 square miles.
Switzerland county...	143,053 acres,	221.96 square miles.
Total	383,113 acres,	598.61 square miles.

A line drawn from the mouth of the Kentucky river to Fort Recovery, Ohio, was the western boundary of the land ceded to the United States by the treaty of Greenville, Aug. 3, 1795. This line is known as the Old Indian Boundary, and separates Dearborn and Ohio counties from Ripley.

TOPOGRAPHY.

As we pass from the Ohio river to the higher parts of the district, we observe a pleasing variety of hill, valley and plain. On leaving the river bottoms and terraces, which are often a mile in width, we ascend the comparatively rugged, but fertile river hills, then pass over broken upland and reach the wet flats where there is often so little natural drainage that water stands on the surface under the oak and beech timber a great part of the year. Hence the local name *slash* given to such land, perhaps from the sound produced in walking over it. The rock formations of this district consists of layers that were originally deposited horizontally, and the Cincinnati uplift affected the whole district so uniformly that very little dip is observed. We can not therefore, attribute this variety of topographical features directly to any upheaval of the rocks, or dislocation of strata. Neither have I seen any marks of erosion that can be attributed to glacial action, unless the broad area occupied by the Miami bottoms and the adjoining terraces be so explained. The valleys must therefore have been formed by streams of water; that is, by the streams that now drain this part of the State, or by those that may have drained it in former ages. It is possible that some changes of the surface were wrought by the tides and currents as the continent was emerging from the ocean, but these agencies could only affect the higher parts, and have not been traced with any certainty.

There is such an intimate relationship between the topographical features and the characters of the soil and agriculture of the several parts of this district, that I have thought necessary to discuss the subject somewhat in detail. As the map will show, there is a portion of flat upland embracing a district near the water-shed, between the White-water River and other tributaries of the Ohio on the east, and Laughery creek on the west. A similar area stretches nearly across the north part of Switzerland county. Much of this land is less flat than a similar part of Ripley county, but

still retains the waters, especially in the native timber, and merits the usual appellation of "White Oak Slash." The most level fields are on the highest ground, forming the water-sheds between the several creeks. As we leave the water-sheds the ground becomes more and more uneven, till by imperceptible degrees we reach the *broken upland*. This will average at a considerably lower level than the flats, but is still high ground; the water here accumulates with sufficient force to wash the soil very badly, if care is not taken to prevent it. The next belt represented on the map includes a still more broken area, which we will term the *hillsides*. These rise abruptly from the river terraces, but can not be distinguished by any rigidly defined boundary from the broken upland. From the "white oak slash" or "crawfish flats," the ravines gradually become deeper, the general surface becomes lower, and the slopes become steeper toward the river and creeks. The base of the hill is very distinctly marked; the other topographical boundaries are selected as the most convenient to present the facts, but they must not be regarded as representing definite lines of demarkation.

The amount and character of erosion displayed in the valleys depends upon the nature of the material to be worn, the amount of water in the stream, and the amount of its fall in a given distance. The larger streams have been acting with such force that a considerable part of their course is now below high water mark of the Ohio River. The points reached by the backwater of 1847, in the larger creeks, are marked on the map. The rivulets that rise on the upland, within a mile or two of the river bottoms, have a fall that enables them to cut deep ravines and make the surface very hilly. The parts farthest removed from the rivers and large creeks, are least affected by erosion, and retain much of the original character of the plain.

It has been suggested that part of the Miami valley may be due to glacial action. This view is supported, besides other circumstances, by the comparative width and the direct course of the area of low land lying on the White-water in Hamilton county, Ohio, and on the Miami below

its junction with that stream. If this is the correct theory, the glacial valley extended at least as far west as Lawrenceburg, and it is remarkable that there is a deep surface valley in Kentucky, from above Petersburg to nearly opposite the mouth of Laughery creek. This Kentucky valley is narrower than that of the Miami, with which it corresponds in position and course. At the lower end is a mass of cemented gravel, about 150 feet in height, commonly called "Split Rock." Similar masses occur below. The hypothesis naturally suggests itself that the valley may be a continuation of the glacial valley described above, and "Split Rock" part of the terminal morain. Slabs of blue limestone occur among the gravel, as though torn from the beds by the advancing glacier.

A table of elevations has been prepared from such data as I could command*. Rigid accuracy can not be expected, even when elevations were obtained by an engineer's level, since all the heights were not measured from a common base. I have assumed the surveys of the Ohio and Mississippi Railroad to be correct, as the base was determined with great care from canal levels. According to these data, low water at Cincinnati is about 410 feet above the sea level.

I have selected prominent points from the upland; the elevations refer to tide water.

FLATS.

Summit of grade near Sunman, Ripley county, 1,007 feet, obtained by the Indianapolis, Cincinnati and Lafayette Railroad level.

Summit of grade near Milan, Ripley county, 1,000 feet, obtained by the Ohio and Mississippi Railroad level.

*I am indebted to the engineers of the Indianapolis, Cincinnati and Lafayette and Ohio and Mississippi Railroad Companies for the use of profiles; and to Messrs. E. M. LeClerc, U. P. Schenk and Grisard, of Vevay, Mr. J. M. Froman, Mr. M. G. Keeney, of Florence, and Mr. Nathan North, of Millersburg, for the use of turnpike profiles and tables of Switzerland county.

General level of high ground in northwest part of Switzerland county, 950 feet, obtained by Aneroid barometer.

Moorefield, 885 feet, obtained by turnpike level.

High point near schoolhouse, one mile south of East Enterprise, 910 feet, obtained by turnpike level.

Quercus Grove, 870 feet, obtained by turnpike level.

BROKEN LAND.

Dillsborough, 785 feet.

High points, southwest part Switzerland county, 875 feet, obtained by Aneroid barometer.

Ridge, south of Guilford, 775 feet, obtained by Aneroid barometer.

"Seminary Hill," near Vevay, 700 feet.†

RELATIONS OF TOPOGRAPHY TO HISTORY, ETC.

Topographical features bear an intimate relation to the engineering of roads and railroads, and therefore to the histories of these counties. In laying out a road from the low land on the river, towards the interior, advantage is often taken of the broad creek valleys, to secure an easy grade, and give an outlet to the fertile bottoms and hillsides. Convenient access to most of the high land, however, is gained by locating the roads on the various ridges that slope towards the river. Here were constructed the principal thoroughfares across these and adjoining counties, and here sprang up many small towns, as Yorkville, Mooreshill, and Dillsborough. When the railroads were afterwards made across Dearborn county, with an ascent of 500 feet, an easier grade was required; and to gain this, the valleys of the Tanner's and South Hogan creeks were selected. Much of the travel was thus diverted from the ridge roads, town property ceased to increase in value, or even depreciated; and in one village there is now no tavern where two were once supported.

†The elevation of this point above the river at Vevay is 304 feet, as obtained by Mr. C. G. Boerner, to whom I am indebted, also, for other assistance.

I can not leave this topic without a remark upon the character of the scenery, which indeed is a very important geological feature. The blue limestone region presents no perpendicular cliffs.* Cataracts also are incompatible with the nature of the rock. Where the ground is uneven, the hills are beautifully rounded, the ridges gracefully sloping to the bottoms, or marked by "saddle-backs." There is no grandeur in the view to fill the mind with awe, but there is a tranquil beauty in the contour of hill and valley, there is a certain loveliness in the aspect of the river, slumbering on the bosom of the rich alluvial terraces, that inspires the mind with thoughts of peace and rest. Even where the ground becomes more level, a vista of four or five miles may be enjoyed from favored spots.

STREAMS AND WATER POWER.

Each county fronts on the Ohio river, and is drained by the tributaries of that stream. The Miami river touches the southeast corner of Dearborn county, and the White-water flows through the northeast part. Tanner's creek empties into the Ohio near Lawrenceburg. North and South Hogan creeks unite in Aurora, near their mouth. Laughery creek flows southward through Ripley county, then southeast, forming the boundary between Dearborn and Ohio counties. The streams of Switzerland county are comparatively small; the principal are Grant's, Bryant's, Log Lick, and Indian creeks.

These streams give efficient drainage (usually towards the southeast) except in some parts of the upland flats and a few spots on the terraces. The valley of Laughery creek, divides our district into two natural divisions, as a study of the topography shows; for the flood of 1847, reached a point five or six miles from Ripley county.

The great amount of fall in many of the streams, early suggested the value of the water power, which has been utilized in many places. The flow of water, however, is so

*One exception is noted in chap. i.

uncertain, that many of the mills can run but part of the year; and as this difficulty has increased, many of them have been abandoned. There is abundant testimony that the summer streams are less constant now than they were some years ago. This change may be attributed to clearing the wet highlands and their more speedy drainage in the spring, rather than to an actual change in the climate. Since the fields have been cleared and plowed, also, much of the water is absorbed by the soil and given up again by evaporation, that would otherwise have flowed off to the creeks.

RISE AND FALL OF THE OHIO RIVER.

The annual floods of this stream are subject to great range of variation, both in the amount of rise and the time of year at which the maximum is reached. The record kept at Cincinnati Water Works for the years 1859 to 1871, inclusive, shows that the highest water for the several years has occurred in each of the winter and spring months, and the lowest water in each of the summer and fall months except June. The water in the channel has fallen, in each of these years, as low as five feet eight inches, and has risen as high as forty feet six inches. The river stood at two feet four inches, Nov. 1, 1862. Two feet six inches is called "low water mark." The most remarkable floods of which we have definite records, occurred in February, 1832 and December, 1847. These floods were sixty-two feet above low water, and the level then reached is generally called high water mark. Floods of 1792 and 1815, are supposed to have been about five feet lower.* The highest stage of the river since 1848, was fifty-five feet above low water, reached in January, 1862. The highest floods of this century have thus occurred at intervals of fifteen and seventeen years. If such a periodicity is established by a longer series of observations, it must indicate the recurrence of climatic conditions, favorable for an accumulation of water at one time.

*See Howe's *Historical Collections of Ohio*, p. 224.

SPRINGS AND WELLS.

Good springs are abundant in nearly all parts of this district. Water is generally found in wells at a depth of fifteen to thirty feet. Both spring and well waters are hard from the underlying limestone. Comparatively soft water occurs in the upland drift, as at Milan, Ripley county, and this is preferred for locomotive engines.

Several farmers assert that the number of good springs has increased since these counties were first settled.

There are two springs that have some reputation for alleged medicinal properties. One of these, belonging to Lazarus Cheek, is one-fourth of a mile northeast of Aurora. The water is clear, slightly effervescent, and smells strongly in summer of sulphuretted hydrogen. It is recommended as a tonic, purgative and diuretic. The water issues from the base of the hill, close to the river bottom, and seems to proceed from the native marl, which abounds at this place almost to the exclusion of limestone. A cistern near by was so affected by sulphur water as to be useless. In Switzerland county, almost in the bed of Grant's creek, a few miles from its mouth, is another spring of some repute for supposed medicinal virtue. This water also smells strongly of sulphuretted hydrogen, and I am told that the gas emitted will burn, about a minute if a lighted match is held near. Whether the reputed value of these springs is real or imaginary, I leave for the consideration of the medical profession.

Several other springs, tainted with sulphur and disagreeable salts, occur on the high land as well as low land.

A well was sunk at Aurora by Messrs. Gaff & Baughman, through—

Gravel, sand and clay, about.....	90 ft.
Blue limestone and clay, about.....	130 ft.
Total.....	220 ft.

It is stated that at 160 to 170 feet down, a vein of salt water was found, the quantity of brine, however, being too

small for economic purposes. Mr. Drayton's analysis gives, from eight ounces of water:

Salt.....	115 grains.
Lime.....	2 grains.
Sulphur and magnesia.....	2 grains.
Total.....	119 grains.

This is equivalent to about three per cent. of solid matter, but as the brine was diluted with water used in working the diamond drill, the pure brine may have been stronger.

A dozen or two salt licks and brackish wells have been noted, chiefly on low ground, near the principal creeks. The manufacture of salt will be referred to in the chapter on economical geology.

Near Laughery creek and elsewhere are a few springs tinged with iron; some have an oily scum, which is sometimes mistaken for a sign of petroleum.

CHAPTER II. DESCRIPTIVE GEOLOGY.

GEOLOGICAL FORMATIONS.

The prevailing rocks are Lower Silurian. The Upper Silurian deposits occupy small areas in the northwest parts of Dearborn and Switzerland counties. The dip is hardly appreciable, except in the western part. There is drift on the uplands, and the river terraces consist of modified drift.

LOWER SILURIAN.

These rocks form part of the "Cincinnati uplift." Their usual character has already been described in Dr. Haymond's report on Franklin county, and in the Geological Reports of Ohio. In almost any of the quarries, or escarpments of rock, the blue limestone is seen interstratified with blue marl or clay. The proportion of limestone varies with the locality, but usually not more than one-third the whole bulk is suitable for economic purposes.

The limestone seldom occurs in layers of more than eight inches. There is an apparent layer of sixteen inches in the Lawrenceburg quarry, but it is separated into two or three by partings of clay. Neither does the marl occur in uninterrupted beds of any great thickness. Near Rising Sun there is an exposure of twenty feet, or more, of blue clay, with no limestone more than an inch or two thick: but even here, there is a very thin layer of solid rock at every foot or few inches. The blue limestone is broken by vertical joints at intervals of a few feet or less. The largest piece observed was at Vevay, about ten by six feet. The pieces often approximate to the parallelogram in shape; sometimes this feature is very striking, where the layer is divided into bits by two sets of nearly parallel joints, not running at right angles. A weathered stone often exhibits very narrow parallel grooves on the upper surface. By breaking the specimen they are seen to extend through one-fourth, more or less, of its thickness.

A peculiar form of rock is seen in certain layers whose under surface is almost plain but the upper surface is waved, being crossed by gently curved ridges, two or three feet apart. There is a fine exhibition of this peculiarity near the junction of Bain's branch with Grant's creek, Switzerland county. The layer is 6 inches thick at a ridge, and $1\frac{1}{2}$ to $3\frac{1}{2}$ inches at the depression, being thinnest where the ridges are furthest apart. The overlying stratum of marl fills the space between the ridges, and the next layer of rock is as even as usual. The arrangement of the ridges may be compared to that of a honeycomb in an old fashioned bee-hive. Where one ridge terminates, those adjoining on each side approach each other until the usual distance is restored.

Compact concretions, or mudstones of oblate form, are common in the shale, being most numerous with certain layers.

The freshly quarried rock has a pale blue color and somewhat crystalline fracture. It is usually fossiliferous, and when made up of large shells it often has too open a texture

to withstand the action of the weather. Water penetrates the stone, disintegration begins and irregular partings appear. Some layers are more compact and almost destitute of fossils. These are of a deeper color if freshly quarried, but both kinds, by exposure, become a whitish-gray on the surface. Iron pyrites occur in one or two layers of solid limestone in some localities, and is sometimes mistaken for an indication of gold. Most of the limestone is firm and durable but can not be dressed to a handsome surface. The blue clay is fine-grained and easily cut with a knife; it has a shaly cleavage in the direction of the layers. A smooth or freshly cut surface, when held in the sunshine, shows a beautiful iridescence. It crumbles or "slacks" on exposure and soon produces a fertile soil. Yellow clay takes the place of the blue in the upper part of the series.

The following analysis is from the Ohio Geological Report for 1870, page 460.

BLUE LIMESTONE MARL, WAYNESVILLE, OHIO.

Silicious matter.....	69.60
Alumina and sesqui-oxide of iron.....	10.24
Carbonate of lime.....	12.55
Carbonate of magnesia.....	1.91
Potash and soda.....	5.40
Phosphoric acid.....	0.16
Total.....	99.86

At the quarries near St. Leon, Dearborn county, in the upper part of the series, the rock is compact and bears hammer dressing much better than the average rock of this formation. On exposure it becomes gray. This change begins at the surface, and gradually reaches the center. While this is in progress, the two colors are not blended, but the gray and the blue remain very distinct.

Some peculiarities in lithological structure occur in the Log Lick and East Enterprise turnpike cuts according to the following section :

- No. 1. Fossiliferous blue limestone and clay..... 10 ft.
 No. 2. Compact gray and blue limestone and clay... 11 ft.
 No. 3. Compact, in small pieces, limestone and clay.. 6 ft.
 No. 4. Fossiliferous blue limestone and clay of usual
 character.....

No. 1 includes little that is unusual.

No. 2 resembles the rock near St. Leon. It is gray near the surface, and dark blue at the center. One layer consisted of long pointed pieces, about one foot by six feet, with clay between in the same layer.

The layers of stone in No. 3 consists of pieces from two to eight inches in diameter, set close together. The larger pieces break without showing a fresh surface, and scarcely a sharp corner.

No. 4 extends, probably, to the level of the river. The top of the section is four hundred and forty feet above low water. The absence of *Rhynchonella increbescens*, *Strep-talasma* and *Petraia corniculum* seems to indicate that these rocks are not at the top of the series.

Another peculiar form is seen in certain heavy layers of limestone exposed near the Ohio river opposite Carrollton. Beginning about two hundred and fifty feet above low water mark, we have the following section of rock without the usual joints and almost destitute of the marl that is elsewhere interstratified with the limestone:

- No. 1. Hard limestone, weathered so as to
 show numerous layers..... 4 ft. 0 in.
 No. 2. Harder limestone, in places showing no
 further division into layers..... 4 ft. 6 in.
 No. 3. Like No. 1..... 10 ft. 8 in.
 No. 4. Like No. 2..... 4 ft. 4 in.
 No. 5. Like No. 1..... 5 ft. 0 in.

Nos. 2 and 4 sometimes form overhanging ledges.

Calcareous tufa, inclosing recent *Helices*, is formed in the cavern. These beds may be traced two or three miles on the south face of the hills. Large masses that have rolled down the hillside show that the rock is very firm. The

position of these rocks, and their fossils induce me to consider them Lower Silurian, in spite of their anomalous lithological character.

Among the lowest Lower Silurian rocks exposed are layers of compact stone of comparatively dark color and abounding in fossils. This rock crops out in Millersburg, one mile from Florence, and at other points on the river. The stone is quarried nearly opposite Rising Sun, at low water, and used for tombstones under the name of "Kentucky marble." It receives a beautiful polish, when the fossils are very distinct; some dull spots probably indicate the position of concretions through the rock. Small cavities lined with calc spar sometimes occur and small crystals of iron pyrites are frequent. Slabs are quarried as large as desired.

In different parts of the series, thin layers occur which have a sand-like texture and a rusty or brown color. Some specimens are almost as fissile as shale, and are found adhering to the usual form of limestone.

In the railroad cut above Weisburg there is an exposure of about ten feet of loose yellow sandy material. This bed contains one ten-inch layer that is pale, blue and pretty firm in the center, but is yellow and crumbling near the upper and lower surfaces. Other thin layers occur similar to the upper and lower parts of the one just described, besides one-half inch of crystalline blue limestone. Some clayey layers also occur. This is equivalent to the rocks described as the upper beds of the Cincinnati group in the Ohio Geological Reports for 1869, page 147, and 1870, page 267, and by Prof. E. Orton, provisionally regarded as equivalent to the Medina sandstone of New York. (Ohio Geological Report for 1870, page 268.) Some of the wells near Weisburg show a blue rock of sandy texture, easily cut with a knife, which is probably the same deposit, unchanged by the decomposing action of frost, air and water. Similar rock is found in wells in Ripley county, northwest of Dillsborough, and in the northwest part of Switzerland county, also in the quarry of Mr Hotchkiss, near Bennington, who has shown

it to possess hydraulic properties. The *Favistella stellata* (which, according to Prof. Owen, marks the upper limit of the Lower Silurian) was not found in the section at Weisburg, but occurred one or two miles south of Mr. Hotchkiss' quarry at a somewhat lower level.

Nearly all parts of this series abound in fossils, but only the lower order of animals and plants are represented. Specimens from various localities have been sent to the State Geologist for identification. By studying these relics we learn that during the ages that were occupied in building up this formation, many changes occurred in the life of the ocean-world. The thimble trilobite (*Trinucleus concentricus*) abounded in the earlier part of this age, but was afterward very rare. The star coral, (*Constellaria stellata*), and other fossils, are confined to certain horizons, while the upper fossiliferous beds are distinctly marked by the *Rhynchonella increbescens* and *Streptoplasma corniculum*. Numerous parasites flourished, as the *Tentaculites flexuosa*.

The exact equivalent of these rocks with those of New York is hard to determine. We have many fossils that are catalogued by Professor Hall, some as characteristic of the Trenton, and others of the Hudson period. Some of the species seem to have a wider range here than is indicated in the New York Reports.

UPPER SILURIAN.

The characteristic fossils are the safest means of distinguishing the several periods of geological history, but well preserved specimens are so rare in the Upper Silurian rocks of Dearborn and Switzerland counties that I was compelled to rely upon the lithological character and the position of the strata to distinguish them from the rocks below. This formation does not appear in Ohio county, but overlies the Lower Silurian in two small areas which are separated from each other by the valley of Laughery creek.

There are good exposures of the weathered rock between Weisburg and Van Wedden Station. Some firm layers occur one foot or more in thickness. Intermediate with these are softer limestone and shales.

The exposures in Ripley county, on the Ohio & Mississippi Railroad, between Laughery creek and Osgood, show the same general character. One layer of 21 inches is there quarried; but where the heavier layers crop out, they generally weather so as to disclose one or more partings. The *Favistella* occurs below these rocks. Near the top of the section, within a mile of Osgood, the limestone and shale have all the lithological characters usually seen in the Lower Silurian, and contain *Orthis Lynx*, *Streptoplasma corniculum*, and other fossils. Further west are quarries of bluish stone, buff on the surface, and similar to the rock shipped from Laurel, Franklin county.

Mr. Hotchkiss' quarry near Bennington, Switzerland county, shows several thick layers of limestone, separated by layers of clay not more than three inches thick. The stone is often gray, but the deep blue color in the quarried stone as well as the gray of weathered specimens, are sometimes more decided than in the Lower Silurian. There are several outcrops in Switzerland county of a very hard buff limestone, containing crystals of calc spar. This layer is several feet thick. It contains *Orthis Lynx*, *Strophomena depressa*, *S. filitexta*, and a few other fossils, and is probably the highest layer in the county, but may be entirely local.

Tetradium and *Favistella* are exposed by a small creek in Ripley county, southeast quarter of section 32, township 6, range 12 east.

POST TERTIARY.

There are no deposits that have been identified as belonging to this period, but the bones of extinct animals have been found at several places imbedded in clay or gravel. These generally occur in the low land bordering the Ohio River or large creeks, and in some cases are clearly in the drift, being exposed by the gradual wear of the river bank. The following is a list of the instances:

Mastodon and Mammoth. Part of a pelvis was found at a salt spring on Tanner's creek below Guilford, and a tusk on Laughery creek above Hartford. A tooth was found at

Rising Sun, in the river bank. A piece of a femur and other fragments were taken from a gravel bank at the mouth of Grant's creek. Mr. M. R. Green, near Patriot, informs me that a piece of tusk five or six feet long, somewhat curved, and about six inches in diameter, was found in the river bank near his house. A Mastodon tusk, fourteen feet long, was found in the river bottom, five miles below Vevay. A Mastodon tooth was found on high ground on George Randall's farm, five miles west-southwest from Aurora. It was lying on a stratum of bluish clay, eight or nine feet from the surface.

Dr. Lutton, of Aurora, has a skull of the large black bear, found in clay at Aurora. He has also a bone that closely resembles that of the Irish Elk. Dr. J. W. Baxter, of Vevay, says that the bones of a sloth were found in the drift above the mouth of Bryant's creek. These bones and teeth are nowhere so abundant in my Geological district as on Big Bone creek, Ky., where they are imbedded in stiff clay and well preserved.

Our study of these remains is rendered difficult by the scarcity and fragmentary character of specimens. Whenever indications are seen of a good specimen, the greatest care should be taken not to disturb it until everything is in readiness to do the work thoroughly; then every piece should be carefully removed, cleaned, and subjected to some process to preserve it from the disintegration that very speedily ensues if the bone is exposed to the air without this precaution.

DRIFT.

There is more or less drift on nearly all the high land. Northwest of Manchester, at Fairview, and in other parts of the upland flats, the limestone is overlaid with unstratified blue clay, containing pebbles and bowlders, many of which bear glacial scratches. The impervious nature of this clay determines, to a great extent, the agricultural character of the "crawfish flats." Much of the drift has been removed by erosion from the broken upland, but even

on the hills, some pebbles are found (occasionally scratched), which must be referred to this source. Boulders are common in each of the counties, some of them three or four feet in diameter.

An interesting specimen, found near Tanner's creek below Weisburg, was a piece of native copper, weighing twenty-six ounces, which must have been brought by natural agencies from the Lake Superior region.

An unusual amount of pebbly drift occurs on the hills near Florence, and at the base is a mass of clay mingled with pebbles, on which no scratches were observed.

At Hartford, there is a remarkable accumulation of drift, chiefly resting against the north face of the native hill. Between the bottoms of Laughery creek, and the hilltop, the deposit is about two hundred feet high, with a beautiful grassy surface, divided by narrow dells. An outcrop through the soil shows nothing but cemented gravel. Time has been wasted here in searching for lead. Sand, with some cemented layers, was found near the top. At the base are slabs of blue and gray limestone, mingled with clay, a variety of pebbles, and flattened ferruginous concretions, which consist of concentric layers or are hollow. A trilobite (*Calymene*) with the form and markings uninjured was here associated with scratched pebbles. In one of the prospect holes there is about twelve feet of quicksand in a basin of native rock. Large crystalline boulders abound south and southwest of Hartford, occupying a space one mile east and west by one-fourth mile north and south, in a valley that opens towards Laughery creek. Two or three small streams flow northward across this valley to the creek.

Chemical changes have taken place in the material of the drift, since it was deposited. Cemented gravel occurs at Hartford and was found in a well near Van Wedden's Station. Split Rock, Ky., is thoroughly cemented by lime and the same change has taken place in many parts of the river terraces. The bog ore described under economical geology, is deposited from the waters of ferruginous springs. A similar substance, but whiter and of limited extent, occurs

in the "crawfish soil" near East Enterprise, and in a clay terrace near Hickman's Landing. Small hard smooth ferruginous nodules occur in parts of the upland flats, where they are said to dull the plow. Brittle concretions, one to three inches in diameter, similar to those at Hartford already described, occur on broken upland one mile west of New Alsace. Radiating crystals of carbonate of lime, almost transparent, but stained to a pale yellow, occur at Hartford, at the base of the drift, adhering to gravel and to limestone.

A phenomenon of interest, but quite local, is the occurrence of vegetable remains in the drift. Mr. N. Van Osdel gave me the following section of his well, in the broken upland of Ohio county, northwest quarter section, 6, township 3, range 2 west:

Soil and clay	22 ft. 0 in.
Yellow sand, quite hard or cemented..	9 ft. 0 in.
Blue clay, quite hard, without pebbles.	1 ft. 6 in.
Rotten leaves, twigs, black soil, wood (believed to be walnut), and thick bark.....	1 ft. 6 in.
Coarse sand, gravel and shelly stone...	9 ft. 0 in.
Hard blue limestone.....	1 ft. 0 in.
	44 ft. 6 in.

Similar deposits occur on gently rolling upland, in the northwest part of Switzerland county. The most interesting of these is at Mr. J. B. Gordon's, in section 4, township 5, range 12 east. The section as described to me is as follows:

Soil, clay, etc., more whitish at the lower part.....	22 ft. 0 in.
Blue mud, resembling recent alluvium	6 ft. 0 in.
Black soil containing leaves, cedar wood and ochreous particles.....	3 ft. 0 in.
Small stones packed together like a Macadamized road.....	1 ft. 0 in.
	32 ft. 0 in.

The bottom layer would be called "rotten limestone," if found in a quarry, and is probably native rock. Several wells in the vicinity are said to have furnished specimens of wood, etc., and one near Aaron Postoffice, some leaves and poplar bark at a depth of 32 feet.

West of the ridge on which Mr. Gordon lives, the rock is much nearer the surface than it is on the east. At a depth of 10 to 14 feet in the well, ledges of rock were projecting on the west side only, while no rock was found in the old well 25 feet further east. These ledges are of a sandy texture, and yellow except a narrow blue portion at the center. They closely resemble a layer, already described, from the Weisburg section, and like it, have probably been peroxidized. Buried vegetation is found in Highland county, Ohio, and many other places. That disclosed in these wells may be of similar origin.

Modified drift is described in the next article.

RIVER TERRACES.

The Ohio river, its bed, and the adjoining lowlands, have been the subject of very interesting changes, especially as the agencies are still in operation, producing results that can be observed from year to year. The Ohio, as proved by borings at several points, "runs in a valley which has been cut nowhere less than 150 feet below the present river." [See Ohio Geological Report for 1869, p. 26.] The many tributaries have since brought down gravel, sand, clay and mud, thus filling up the valley to the present level of the river bed and the adjoining lowlands. The source of this deposit is to be found in the several formations, including drift, over which the river and its affluents have flowed. The deposit, or at least the upper part, exhibits a stratified arrangement, and is called modified drift.

Let us first consider the surface features. The river flowing from one side of this area of lowland to the other, is even more winding than the valley of erosion prepared for it. The bottoms extend on both sides of the river. except at intervals where the water strikes the native Silurian rock

and is deflected in the opposite direction. The aggregate width of the river and lowlands, within the district we are considering, is usually from one and a half to two miles.

The lowland generally consists of a series of terraces,* rising from the river to the hillside, of native limestone; and the whole area varies in width at every mile as the river passes toward either shore. The terraces vary in number, height, and slope, conforming to no apparent law. For convenience, they may be classed as high and low terraces, and gravelly knolls. No correspondence is observed in the height of the terraces on the opposite sides of the river. More than half of this lowland area is included in the high terraces, which rise above high water. The surface may be gently rolling, and is often divided by a low water shed parallel with the river, the greater part being drained toward the hill, at the base of which is the channel of a wet-weather stream. The greater part of the low terraces are subject to overflow in time of the highest floods. They often slope toward the river, and under favorable circumstances those which are subject to frequent overflow receive an additional deposit of rich alluvium.

Low terraces sometimes occupy nearly the whole space from the river to the hillsides; for example, at the mouth of Plum creek and the first mile below; at Florence, and at the mouth of Bryant's creek, and the first mile above. In the first instance, the high terrace lies on the west, separated by a well marked bench, while the low terrace is reduced in width to a few rods, and entirely disappears below the warehouse at Vevay. The same features are presented at Florence, most of the area between the lower part of Log Lick creek and the Ohio being occupied by high terraces. The low terraces at the mouth of Bryant's creek extend west to a point where the river strikes the native rock, but are reduced to a very narrow strip on the east, where they are bounded by high terraces. Such variations, as well as others, may be noted throughout the river portion of the

*The river bottoms are all included in this term..

district we are considering. At one place, a terrace presents an unbroken surface of gentle and uniform slope. Either above or below, the surface may separate into two or more terraces, one being from two to twenty feet higher than the other. A terrace may have a gradual slope in the same direction as the river current, or in the opposite direction. I have seen no instances of such regularity as represented in the view of the Connecticut river terrace in Dana's *Manual of Geology*.

At or near the base of the limestone hillsides, gravelly or sandy knolls and ridges occur at certain places. These are higher than any of the terraces described, and present a more uneven surface. Examples will be seen north of Rising Sun, and near the mouth of Plum creek.

If we observe the material of which these deposits consist, we find a great variety; limestones, sandstones and shales are mingled with various crystalline rocks. All kinds of rocks that are common in the Ohio valley are here represented. Fair specimens of certain corals sometimes occur. Coarse and fine sands are interstratified with gravel, sometimes with clay. The gravel beds are often cemented where they are exposed or near the surface. It is noticeable, also, that the higher terraces are older, and consist of coarser material than the lower ones.* This is seen where a section of a high terrace and adjoining low terrace are exposed together, as at Vevay. Five to fifteen feet near the surface is generally sandy, resulting in part from the decomposition of coarser material. With this exception, the high terrace contains coarse gravel and boulders through the whole depth as far as exposed, while the low terrace at the same level contains finer material only. The lowest terraces consist of the very fine loam deposited by recent floods.

While a half dozen terraces can be distinguished on some parts of the Ohio, its tributaries do not exhibit so many. Two are distinctly marked on parts of Laughery, Hogan

*For this observation and other aid in studying this subject, I am indebted to Hitchcock's "Illustrations of Surface Geology."

and Indian creeks. The larger creek channels have been eroded much deeper than their present level, and have since been filled by material brought down by the several streams, chiefly a whitish clay, with traces of stratification. A well near Laughery creek, (two and a half miles from its mouth) disclosed a bed of water-bearing sand at a depth of forty-seven feet.

Other materials than those described occur in this formation. At Lawrenceburg, exposed only at low water, is a bed of blue clay, containing abundant remains of leaves and logs.* The fruit of the buckeye, beech, hickory and buttonwood were recognized. This deposit of organic remains was found also in a Lawrenceburg well. Limbs and pieces of wood imbedded in blue clay were found in a well at Aurora. An excellent exposure of similar character occurs at Hickman's Landing, Switzerland county, two miles above Florence. A bed of blue clay containing leaves and wood, four and a half feet thick, may be traced in the river bank without interruption for twenty rods, and appears at points above and below. Both here and at Lawrenceburg there are ochreous deposits of sand or gravel above and below the clay. At Hickman's Landing these layers are usually cemented, and some thin layers of similar character are interstratified with the clay. The greater part of this terrace (which slopes towards Sand Run) was covered by the floods of 1832 and 1847. At a point near the river, about four feet above those floods, a well was dug reaching the bed described, showing that this is not a recent deposit upon the shore, but it must be older than the terrace which contains it. Another boring disclosed the bed more than a quarter of a mile from the river. Some antiquarian remains now form part of the terraces. In the river bottom, below the mouth of Laughery creek, are the remains of ancient fireplaces. One of these disclosed by the wearing away of the bank was thirteen feet below the surface of the river bottom. Deposits of mussel shells are exposed in the banks.

* This was pointed out to me in 1871, by Prof. E. Orton, of Ohio.

near Florence, from three to ten feet from the surface. These point out the presence of man while those terraces were forming.

Having thus described the present condition of this formation, it will be necessary to study the changes that are now in progress, before framing any theory of geological history. The chief agent is the river itself, now rushing down with a flood of water fifty feet deep, and a few months hence gently flowing with but three or four feet in the channel. Here the current strikes the loose gravel or sand of the bank, and the wind drives the waves against the shore; there the swollen waters have spread beyond their banks, the current is arrested in a shallow place, and particles of fine sand and clay, leaves and vegetable mould, are deposited to enrich the bottom, or to help form a new terrace. In certain places large portions of either high or low terraces become undermined and slip into the water. The united action of frost and wind carry on the same work of destruction. Elsewhere the farmers are extending their cornfields where the waters formerly flowed.

A few examples of these changes will be given: At Rising Sun it is estimated that no less than three hundred feet of the bank has been washed away within twenty-five years. A row of houses has disappeared which once stood above Main street, with road and play-ground beyond. The well referred to, at Hickman's Landing, was dug about one hundred feet from the bank, but it has been carried away and much of the bottom behind it. At Florence there was but little wear twenty-five years ago, the bank being protected by trees. About eighty feet of the bank have been lost at the Main street within a few years, and two hundred feet a short distance below. Repeated changes of the river road have been required in many places.

The process of land making is also very common, but I judge that the amount of material deposited will by no means equal the amount removed. There was formerly a low island above Vevay, close to the Indiana shore. Steamboats ascending the river frequently passed through the

chute, twenty years ago. The steamer Kentucky went through as late as 1859. A few tow-heads were gradually formed about the upper end. The current was thus arrested and the fine material held in suspension was deposited. When this accumulation had so filled the chute that the island was connected with the main land at low water it became part of Indiana; another corn field has been added to the agricultural wealth of the State. A stump, which was at the water's edge in 1850, to which the fisherman fastened his net, is now several rods from the bank. Land is still forming among the trees beyond and below the island. Similar deposits are generally forming wherever a growth of willows or other trees is secured sufficient to diminish the current in time of overflows. Sometimes, however, the exposed roots of trees indicate that they are not a certain preventive of erosion. The current may be even wearing the bottom at one point while depositing silt immediately beyond. For practical suggestions on the protection of river property, see the chapter on Agricultural Geology.

Let us now consider what hypotheses will most readily account for the observed facts. We will assume, with most geologists, that the drift phenomena prove a "glacial period," when the continent was raised far above its present level. This period preceded the formation of the terraces; beside other proof, this is indicated by the variety of the material, for the terraces contain crystalline boulders from the drift as well as sedimentary rocks that are native in the Ohio valley. During the elevation of the continent, the erosive power of the Ohio and its tributaries would be augmented by the increased amount of fall in the streams. This easily accounts for the wear of the rock formations to the depth required below the present river bed.

During the "Champlain Epoch" which followed, the continent subsided, the force of the current diminished, and the coarse material brought down by the stream was deposited. This process must have continued till the highest parts of the present terraces were reached by the flood. The creeks, meanwhile, left a deposit of clay from the Silurian hillsides.

The terraces have not yet been accounted for. The river bed is now far below its former level, and we must call to our aid one more period of continental rise to explain the erosion that followed the Champlain Epoch. Whether this part of the continent is still rising has not been determined by historic data, but we have seen that the "Terrace Epoch" is not yet at an end. Partly by the erosion of the river at certain places while deposits were forming at others, and partly by the agency of tributaries, the ever changing series of terraces may be accounted for. The height at any point will depend simply upon the amount of erosion and the depth of deposit. As already noticed, the high terrace has entirely disappeared near the mouth of several of the creeks. The material that has been worked over and re-deposited is finer than that of the original formation, as noted at Vevay; but we may not always be able to determine whether a certain bottom should be referred to this epoch, or to a denuded part of the original deposit. During this epoch or the preceding, soil was formed, and various trees flourished such as are now common in temperate regions. These remains are not found through the whole deposit, because either their growth or the conditions for preserving them were local; but it will be observed that the deposit at Lawrenceburg is twenty or thirty feet below that at Hickman's Landing, and could not have been made at the same time. The antiquity of the vegetable remains in these instances is argued from the overlying deposit. That at Hickman's Landing was made at a time when not only could the river rise four feet higher than the greatest floods of historic times, but the circumstances were favorable for the formation of river bottom at this height. Wood and leaves are still buried every year by the alluvium, and may be unearthed in the future. The old channel at Vevay island is now occupied by a pile of drift-wood. By the operations now in progress, this may be completely covered and preserved. A future race, digging a well on the river bottom, may find the same phenomena that interested us ten miles above.

Professor Hitchcock's conclusion, drawn from the study of terraces elsewhere, is equally applicable here. The successive terraces, he says, "may be found by the simple drainage of the country, as the surface emerges from the ocean. Nor need we, as has generally been thought necessary, suppose that there were pauses in the vertical movement."

(Illustration of Surface Geology, p. 58.)

RECENT GEOLOGICAL CHANGES.

The line between geological and historical times can not always be distinguished; the "Terrace Epoch," as we have seen, includes the present time. Whenever a flood washes the soil from the hillside, or tears up the stone from the brook, the process of erosion is in progress. The frost, the rain, sunshine and plant-growth, still carry on the work of soil-making, just as in prehistoric time. The calcareous tufa of Switzerland county, while regarded as a recent formation, is governed by the law of chemical geology.

Another interesting phenomenon is the formation of sink-holes. These are most abundant in the soils overlying the Upper Silurian rocks, or the upper part of the Lower Silurian, where the water sinking through the soil wears away a channel by dissolving the rock, and the soil, no longer supported, falls in. A very common form is that of an inverted hollow cone. This may increase, if the water is allowed to wash down more and more of the soil to the channel below, but if it becomes sodded over, (especially when filled with brush or rubbish), the wash may be arrested, and the sink be converted into a pond, and gradually filled up.

When the surface soil is matted together by the roots of grass, it will keep its place long after the cavity has begun to form, until finally some horse puts his hoof upon the fragile roofing, and a cavity is revealed large enough to hide the whole animal. The next year the hole may be filled.

A series of sink-holes sometimes points out the vein of water, when a well is to be sunk, or an opening in a layer of rock, when a quarry is to be opened.

A common phenomenon is the land-slip, especially on the steep river hills. The clay, being wet with spring rains, becomes slippery and too soft to support the weight above. Part of the hillside slips down by its own weight, forming a bench where the material accumulates. A greater depth of soil is retained on the benches than on the steeper part of the slope.

ANTIQUITIES.

Dr. G. Sutton, of Aurora, kindly promised to furnish an account of the antiquities of Dearborn county, and these will not be considered in this article.

Artificial mounds, as well as darts and other implements, are numerous in Ohio and Switzerland counties, near the Ohio river and Laughery creek. They are often associated with burial places, either in the bottom or on commanding eminences. I have found no mounds on the upland flats, though other relics sometimes occur, as a beautiful heart-shaped ornament of Huronian shale, found near Bennington.

Dr. J. W. Baxter, of Vevay, gives me the following account of a series of mounds or signal stations, occupying prominent points along the Ohio river, and so located that each may be seen from the next above and below. These command nearly the whole bottom. From the station below Patriot the observer may look across Gallatin county, Kentucky, and the valley of Eagle creek to the high of land in Owen county. Both this mound and one near Rising Sun exhibit traces of fires that were doubtless used as telegraphic signals by the Mound Builders. The mounds at the following places form a complete series, though others may have been used when the country was timbered :

Rising Sun.

Near Gunpowder creek, Kentucky.

The Dibble Farm, two miles south of Patriot.

The "North Hill," below Warsaw, Kentucky.

The Taylor Farm, below Log Lick creek.

Opposite Carrollton, Kentucky.

Below Carrollton.

A greater number of wild grapes, plums, crabapples and onions are found near the mounds than elsewhere.

Dr. Baxter refers these relics to the same race as the natives of Central America, from the similarity of hieroglyphics on pottery found near Warsaw, and from the features of a face carved in sandstone from the same locality.

The fireplaces, near the mouth of Laughery creek, have been mentioned in describing the river terraces. These are disclosed from time to time as the river wears the bank. Dr. Grant, of Kentucky, told me he had known at least eight. The one I examined consisted of a layer of bowlders 13 feet from the surface. The part exposed was 3 feet across. Pieces of charcoal, soft and crumbling, were found among and under the bowlders, while other pieces, that had fallen out and dried in the sunshine, were firm. The clay under the bowlders was red as though burnt. No one could examine the section without being convinced of human agency in the work.

In the river bank, opposite Florence, there is a layer of decomposing mussel shells, thirty-two inches from the surface. The outcrop now extends forty feet, and was noticed as early as 1847, when the bank stood two or three rods further towards the channel than it now does. This deposit seems to be entirely local, though extending over several square rods. The shells include *Unios*, such as are still common in the river, and are so far decomposed that the laminated structure is plainly marked, as in shells that have been burnt. Similar deposits have been observed elsewhere in the terraces.

CHAPTER III.—ECONOMIC GEOLOGY.

BUILDING STONE.

The blue limestone is everywhere abundant, and is well adapted for foundations, cellar walls and other rough masonry. Very little of it will bear dressing. Houses made of this stone may be substantial, but are not handsome; they be-

come discolored with age, and sometimes stained with iron; stones of coarse texture weather badly. Few quarries are extensively worked, because the stone may be picked up from every creek, or dug out of almost every hillside. This limestone is less liable, than the Cliff, to split and fall to pieces under the action of fire. J. R. Kilner, of Lawrenceburg, pointed out an illustration of this fact in the foundation of an old warehouse near the I. C. & L. depot. The building was burnt, with about one hundred tons of hay and many thousand empty barrels, but the rock foundations suffered little injury. Large slabs of compact stone are selected for fireplaces, and last fifty or sixty years. The smaller stones are much used for Macadamizing roads where gravel can not be obtained.

The so-called "Kentucky marble," used for monuments, has been described.

Quarries near St. Leon and Weisburg furnish a superior stone, approaching that of the Upper Silurian in color and compactness. This stone resembles that of Schrichte's quarry, near Brookville, described in the Report for 1869, p. 181.

The Upper Silurian quarry of George A. Hotchkiss, near Bennington, furnishes excellent building stone, which was used in the jail at Vevay. A difference is observed among the several parts of the quarry: the stone from one layer having been tested for nearly twenty years is scarcely affected by exposure. The stone is grey on the surface, but is often of a dark blue color when broken. It is compact, and contains few fossils. A similar stone occurs in Dearborn county, one mile south southwest of Mooreshill, and is quarried near Elrod, Ripley county. Both these localities furnished stone for the bridges of the Ohio & Mississippi Railroad.

LIME.

Lime is burned for home consumption, in temporary kilns or in "log heaps." If the latter method is selected, the stone is laid on a pile of logs (the large pieces being

broken) and burned about one day. When the fuel is exhausted, although the stone is not all thoroughly burnt, some good lime is made. This method requires several times the quantity of wood needed in the kiln, and is now more seldom resorted to, since timber has become less abundant. There are no perpetual kilns. The blue limestone from the surface or the creeks is generally used. This makes a dark colored but strong lime, well suited for mortar, though it will not answer for the skim, or for whitewashing. The same kind of lime is used by soap manufacturers in Cincinnati to prepare the caustic lye. The dark blue compact layers produce a much whiter lime than the fossiliferous rock.

HYDRAULIC CEMENT

Has been made by Mr. Hotchkiss, near Bennington, from the lower layers of his quarry. This stone resembles in general appearance the massive beds at Madison, lying above the *Favistella* layer. It seems to be the geological equivalent of these beds and of similar outcrops near Weisburg, but there are no fossils to prove the identity. It is a pale blue stone, turning greenish on exposure to the weather. The lowest layer that has been worked is darker. There are some irregular streaks of hard limestone, especially in the upper layers, which underlie the building stone. On burning it becomes greyish yellow, and the ground cement, when pressed with the finger, has a glossy appearance. It hardens more quickly under water than in the air. A specimen mixed with half its weight of sand, and made into a cake three-eighths of an inch thick upon a piece of stone and immersed in water, was hard, and had a perfect gloss at the end of fourteen hours. Mr. Hotchkiss says the cement does not check in drying, and that it sets under water in fifteen minutes, and the continued action of water for some months only seems to harden it. It adheres strongly to stone. Specimens may be seen on outside stone work that have been exposed to the weather since the fall of 1871, and seem to become harder with age. The distance of the quarry

from a railroad or the river is one of the chief difficulties in the way of establishing manufactures at this place on a large scale.

A similar stone crops out at various points near the junction of the upper and lower *Silurian* in Jefferson, Switzerland, Ripley and Dearborn counties, but no satisfactory tests have been made within my district, except at the locality specified. Further experiments should be made to prove its durability and its fitness for cisterns. Still more satisfactory results may be obtained by burning the stone for a longer time, or with a more regular heat than could be maintained in the kilns used.

BRICK, FIRE CLAY, ETC.

Bricks consist essentially of clay, moulded into convenient form and hardened by drying and burning. Pure clay will warp and crack. A certain proportion of sand is needed to make the clay porous, and let the moisture escape from the interior of the mass. Too large a proportion of sand makes the brick fusible. Pebbles of any kind are to be avoided, and little pieces of limestone are especially injurious, as they are converted into quick lime, and when the bricks are wet this absorbs moisture and swells, breaking the brick.

Suitable material for brick making occurs in most parts of these counties. There is a brick-yard at New Alsace, on the yellow clay of the broken upland. The "crawfish" clay of the upland flats near Enterprize, is used, but is rather too tough. Among the terraces there is a variety of material from which to select. At Newtown, the recent alluvium is used, mixed with a due proportion of sand or sandy loam. At Rising Sun, the material is taken from an older terrace. The upper part contains too little sand; but a suitable proportion is found at a depth of ten feet, and the clay at six feet, answers well when mixed with that from below. An old lime-kiln, a section of which is now exposed in the bank, distinctly shows the action of heat on the several parts. The clay wall at the bottom is still hard and firm;

but as the sand diminishes towards the upper, part the wall becomes more and more crumbling.

A blue fire-clay occurs in Mr. Hotchkiss' quarry, in layers of three inches and less. It turns yellow on burning. Where the river terrace slopes toward the hill, as at Vevay, a stiff blue clay sometimes occurs, which may be derived from the native marl washed from the hillside. This mixed with sand is recommended for setting grates. It is said to be better for steamboat furnaces than genuine fire-clay.

Red pottery-ware was made at Vevay fifty years ago. Yellow-ware was also made near Rising Sun, and stoneware from blue clay on Arnold's creek; but these manufacturers were long since abandoned.

Drain-tile is made at Sunman's, Ripley County, and near Madison. For this purpose a purer clay is required than for brick. A premium was offered by the Switzerland and Ohio Counties Agricultural Association, for the establishment of this industry in either of these counties. If the demand should warrant the enterprise, suitable clay can be found at certain places.

GRAVEL

Suitable for roads is found at many places in the river terraces, including those of the Whitewater and Miami. No suitable deposits are accessible on the high land.

MOULDING SAND

For heavy work is procured from the railroad cut near Newtown. Kettles eighty-four inches in diameter are cast by Mr. Stedman, of Aurora, in the green sand; for light work this is mixed with sand from the Ohio River.

SALT.

The manufacture of salt was carried on in early times, when transportation was difficult; but this industry was long since abandoned, as there are no salt wells or springs

strong enough to make it profitable. There was a government reservation kept for this purpose on section 25, township 6, range 1 west. Salt was made in the early part of this century on Grant's creek, at the mineral springs already described—ten or twelve kettles used. The Indians are said to have made salt at this place. Several bushels were made in 1840-42, in Jefferson county, from a boring on section 12, township 5, range 11 east. Borings of about 200 or 250 feet were made at Hartford, with no satisfactory results. It is said that thirty gallons of water from a salt lick in Dearborn county, near Hartford, were evaporated by Mr. Wilber and produced nearly four pounds of salt, which was pretty good, but yellowish. Salt was obtained from a boring at Jacksonville, Switzerland county, but the brine was too weak to be profitable.

FERTILIZERS.

There is an abundance of limestone which can be cheaply burned. No beds of gypsum are found.

There is a small quagmire near Hartford, rich in decaying organic matter, which may prove to be valuable.

The blue marl which is interstratified with the limestone, contains a good proportion of phosphates, and Dr. Locke, of Ohio, says it would be a valuable fertilizer.

Mr. Drayton and Col. Mitchell, of Aurora, propose to manufacture a phosphate, for agricultural purposes, from the blue clay or limestone of that locality.

Remarks on the use of fertilizers will be found under Agricultural Geology.

IRON ORE.

Good bog ore occurs in many parts of the broken upland, but has not been seen elsewhere. In each spot it seems confined to a few rods or a few acres near the hilltop, but several outcrops occur near one locality, as near Quercus Grove. There are ledges from six to fourteen inches thick, but the stratum is seldom continuous, being divided into pieces a yard or less in diameter. Drift pebbles occur

through the mass in many cases. The ore is most frequently noticed at the surface, or where struck by the plow, but it has been seen eight or nine feet deep. No great depth is to be expected, as the limestone occurs below. In one or two localities the soil is barren, but farmers generally say they observe no difference in this respect. If the ore exists in sufficient quantities near good shipping points, it may prove valuable.

The principal localities in Dearborn county, are near Guilford, and Dillsborough; in Ohio county, on James Kittle's farm, section 5, township 3, range 2 west; on A. Barrecklow's, section 30, township 4, range 1 west, and on Benjamin Miller's farm, near Rising Sun; in Switzerland county, on several farms near Quercus Grove, and several farms northwest and northeast of Vevay.

LEAD.

There are traditions that the Indians gathered the ore by the apron full, and pieces of galena have been picked up in various places, but no vein has been discovered, and I have seen no specimen known to belong to this geological district. The long continued unsuccessful search has proved that no workable ore is to be found. Some of my inquiries ended in such information as this: A says that B said that a certain person thought he could point out the mine!

GOLD.

Dr. Dorsey of Hartford, examined the drift of that region, and found one small particle of gold from two panfuls of sand. Ohio county, is not destitute of this widely disseminated metal, though it does not occur in any paying quantity.

CHAPTER IV.—AGRICULTURAL GEOLOGY.

While this subject is properly one branch of economical geology, its importance demands a separate chapter, which will be devoted especially to the interests of the farmer.

Agriculture is eminently a matter of experience, yet there are certain underlying principles that should be understood in order that the farmer may avail himself of the experience of his brother farmer, who is laboring on a different kind of soil, with different topographical features, different crops, or a different climate. This chapter will embrace some applications of geological truths to the most important industry of this district, and if I step beyond the limits of strict geological science, I trust the effort to make this report a work of practical value will be a sufficient excuse.

The carpenter acquaints himself with his tools, and the various kinds of wood; the iron smelter studies his ores, fluxes and coals, and the agriculturist can not understand too well the nature of the soil from which he would gather his harvests, the changes that are wrought by cultivation, and the most successful means of preserving or increasing its fertility. While the blue limestone region is not rich in mineral wealth, the soils of this district are among the most productive in the State.

DESCRIPTION OF THE SOILS.

A good soil must have certain properties in order to afford a suitable support for the roots and stem of the plant, to furnish the needed food and to bring this within reach of the plant. If it is very light and sandy, the soil may be blown away from the roots, leaving them bare and without sufficient support; the rains, penetrating too quickly, may sink away and be lost, or may evaporate too fast, leaving the crop to perish for lack of moisture. A close, stiff clay soil allows the water to pass through with difficulty; much flows off from the surface. When thoroughly wet, evaporation goes on slowly; it remains wet and is slowly warmed by the heat of the sun. The roots can not penetrate so far as they should in search of food. Several kinds of plant food are always required. The ingredients that are most often lacking (besides moisture) are potash, lime, phosphates, and the products of decomposing organic matter. Some of these

substances exist naturally in small proportions, and by constant cropping the amount becomes too limited to produce good crops.

To describe fully every variety of soil in a single township would require more space than can be allowed to this whole report. A single farm of half a section, may include part of a rich bottom that has just received its annual deposit from the river, a dry gravel terrace, a cold wet clay terrace and rich black hillsides. Even on the same acre, the best of the soil may wash from the poor gravelly red ridges; where the wheat is hardly worth cutting, and enrich the lower parts, which are clothed with a luxuriant growth of grain. While there is such a diversity on every side, there are some prominent features that are most abundant in certain sections. If this district were divided with respect to the prevailing character of the soils, the boundaries would nearly correspond with those laid down on the map to distinguish the topographical character of the several parts. The properties of a soil are observed in handling a specimen, working the field or noting the agricultural products, but we also want to know its origin, the amount of slope and the aspect, or direction of the slope. The erosion to which the land has been subjected may influence its character, and the native timber is a good index of its quality.

The typical soil of the upland flats is derived from true drift, with which it is underlaid. It consists chiefly of stiff, cold, wet clay, of ashen color. Water stands on the surface after a rain. The soil is shallow, for it is too stiff and close to let the roots and moisture penetrate readily. The subsoil, when wet, is very sticky; it adheres to the spade like putty. When dry, it is very hard, the spade will not penetrate it. The ground near the watersheds is called *crawfish* land from the abundance of these animals. Their holes retain water all summer. Where there is more natural drainage, this is not the case. Towards the broken land, in all directions, the soil is more yellow and mellow, and appears to have a larger proportion of sand. This is seen on the surface after a rain, when a rill that has accumulated the sand, spreads

out over a more level space, and dropping the sand, carries the clay beyond. The subsoil, in many places, is a mixture of yellow and bluish clay, with more or less sand. In the northwest part of Switzerland county, fragments of chert are very common, thinning out and disappearing a few miles from Jefferson county.* In some parts of the flats, especially on the wet spots, the hard ferruginous pebbles or concretions abound, referred to in describing the drift.

The prevailing timber of the upland flats varies with the nature of the surface. White Oak and Beach abound. Other oaks, several kinds of Hickory, Black Gum, and Dog wood are common. Poplar, Walnut and some Sassafras, grow near the breaks.

On the broken upland the amount of drift varies according to the thickness of the original deposit and the amount lost by erosion. The limestone and marl add to the fertility where they are exposed to the air or streams. In some parts the rock crops out at the surface, in others there are many drift pebbles, the clay having been removed; in still others, the digging of wells shows the true, unmodified drift. These soils are yellow, except where a large amount of organic matter has accumulated, as in the native forest or by the use of green manure. Although the vegetable mould is generally more abundant on the hillsides than here, yet this soil has the advantage of retaining the moisture better than that which is darker and more mellow.

Sugar Maple, Black Walnut, White Walnut, Beech, Hickory, White Oak, Linden, Elm, and Red bud are common species of timber.

The still more broken land, including the hillsides, contains in the blue limestone formation all the mineral ingredients essential to perpetual fertility, but these must be modified by disintegration and the addition of organic matter, before they can be appropriated by the plant. Some steep, barren hillsides are practically worthless. Having

*The cherty feature, which must be attributed to Niagara rocks, is strikingly exhibited in a railroad cut east of Osgood, Ripley county.

been cleared, or bearing but little timber, they do not support even a good crop of weeds. The soil is washed off as fast as it is formed. In more favored localities a thin white clay soil accumulates, sufficient to produce a scanty crop of wheat. In still others, the forest leaves are mingled with the soil, or a crop of clover has been plowed in, furnishing the organic matter that is needed to make the rich. "black hillsides." Note the fertile slopes near Rising Sun, where the hills are covered with a garland of trees. A farm on Grant's creek produced satisfactory crops of corn and wheat for fifty years, when it was thought necessary to restore the land simply by raising hay. This is not an exceptional instance, for the hillside farmers claim that a proper rotation alone is necessary to maintain the fertility unimpaired. As every crop taken from the field withdraws some potash phosphates and other plant food, it must not be supposed that the same soil will yield undiminished crops. Every rain washes something from the surface toward the creeks, the water takes up carbonate of lime from the surface of the rock, and every rootlet that penetrates the marl below aids the frost and sunshine in the process of soil making. Thus the field undergoes a constant renovation, and it is the abundant supply of food stored up in the underlying marl and limestone that give this region its inexhaustible fertility.

The southern exposure is generally regarded as the most fertile, though abounding in loose stones. One farmer says the eastern slope is better for wheat than the western, since the crop receives the benefit of the morning sun and is less apt to rust.

Black Locust and Honey Locust are specially characteristic of the limestone soil. Several Oaks, Ash, Beech, Elm, buckeye, Linden, Wild Cherry, Hackberry and Mulberry also abound. Walnut and Sugar Maple are indicative of rich soil.

The terrace soils remain to be described, which are derived entirely from modified drift and material washed from the several formations of the Ohio valley. The

ingredients are so varied that no essential mineral element is wanting. The creek deposits derived from the blue limestone resemble the hillside soil, in being stiff, clayey and whiteish wherever the organic matter is exhausted, but with this ingredient the creek soil is very similar to the rich, black hillsides.

The gravel of the river terraces would easily admit the air and rain, and quickly yield to these decomposing agencies, producing good land. Some terraces contain gravel only a foot below the surface, in others the soil is deep. There may be an understratum of coarse or fine gravel, or even of fine clay. Some river terraces are very sandy, as the low bottom above Rising Sun. Some are stiff and clayey, as a narrow strip on the north side of the Sand Run; this may be attributed to material washed from the hillsides. The recent river deposits are always fertile, and where a frequent addition of river mud can be secured, no apprehension is entertained that the land will be exhausted.

Willow, Elm and Buttonwood grow near the streams. Soft Maple, Oak, Poplar, Walnut, Hickory, Hackberry, Ash and Buckeye are also native to this soil. Beech, here as elsewhere, indicates a clayey soil. The Black Locust, though abundant on some of the gravel terraces, was probably introduced by man and has since retained its hold.

CROPS.

The chief field crops are corn, potatoes, wheat, timothy, clover, oats, barley, rye and onions. Fruit is raised in all parts, and a few of the farmers give some attention to timber planting.

Corn is especially adapted to the rich bottoms, as these receive frequent additions of rich alluvium from the overflowing river. The crop is sometimes destroyed in these localities by late floods. The higher bottoms, which are not so rich in vegetable matter, are well adapted to wheat. Potatoes and the various grains are extensively raised in all parts except the upland flats. Switzerland county is noted

for the amount of timothy shipped for the southern market. It is estimated that fifteen thousand tons were exported from September 1st, 1871, to July 1st, 1872. The upland flats are better adapted to hay than to cereals. Good crops of timothy are raised, but this grass is crowded out in a few years by red-top, (*Agrostis vulgaris*) which in turn gives place to wire grass, (*Poa compressa*) and others. By proper culture and rotation one good crop of wheat or corn may be raised every few years. Clover is raised to advantage on the more mellow broken land. There is a larger proportion of clover in Dearborn than in Switzerland county, since this is quite as profitable as timothy for home use, and the facilities for shipping south from Dearborn county are not so good. Some onions are exported from Switzerland county.

The fruits most extensively raised are apples, peaches, plums (usually the Damson) and cherries. Pears, quinces and small fruits are also raised, especially for home use. Success depends upon a proper location, to avoid frost, quite as much as upon the nature of the soil. High rolling ground is preferred, since the colder air sinks by its greater specific gravity into the lowest place within reach, and the high points are not subject to the same degree of cold as the neighboring low places. Good apples are raised even on the "crawfish flats," especially on the highest points. On the river bottoms, good fruit is sometimes produced (as in 1871,) when killed by frost on the adjoining hills. In this case it was probably protected by fog.

Timber planting has not received the attention it deserves. Black Locust grows quickly, and will produce a crop of good fence posts with some firewood every fifteen years. Farmers object to its proneness to send up suckers on the adjoining ground; but they may be kept within bounds in groves on rough ground near the ravines, or on the steep hillsides that are worthless for other purposes. The trees should be four to six feet apart each way. If this course is followed, a fertile soil may accumulate on the barren slopes, when they are shaded by the trees and receive the addition

of leaves each year. The cedar thrives on stony bluffs, and is recommended for such places; the larch has also been tried elsewhere if not in this district, and promises to be a profitable tree. Oak, Poplar and Walnut require at least a century to reach their full development, but future generations will require timber, and their needs should be regarded as well as our own.

PRACTICAL SUGGESTIONS ON HUSBANDRY.

The farmer's habits of observation enable him quickly to detect a field of natural fertility that has been *worn out*. By bad management it has been so changed that it will produce but one-half or one-third the crop that was raised on the virgin soil. The products are the criterion, rather than the appearance of the soil. By careful and judicious culture, on the other hand, the exhausted farm, or one not generally fertile, may be so improved as to yield double or quadruple crops. The changes, whether of deterioration or restoration, will depend upon the natural condition of the ground, the crops raised, and all those methods of treating the soil and crops that are embraced in the term, *husbandry*. I have sought to use every opportunity to converse with intelligent farmers and learn the methods they have used, the effects of such treatment and the systems which their experience enables them to recommend for this particular district. It is almost amusing to note difference of opinion on some of the simplest questions. One says that timothy improves the land; another, who is differently situated, that it deteriorates it, and that it was once as easy to raise two tons per acre as it now is to raise one ton on the same ground. One farmer recommends trench plowing, his crops having been improved by it; another tried it on the upland and years were necessary for the ground to recover its former productiveness.

The soil may lose its fertility, as we have seen, by taking the products off the farm each year, leaving less plant food in the ground for the next crop. This process has been carried on in a great part of this district. Some of the upland

has been exhausted by raising corn so that now it is difficult to get grass well set. The timothy crop has been impoverishing the soil more slowly, but not less certainly. It is estimated by chemical analyses that an average ton of timothy hay contains :

Potash	40 lbs.
Lime.....	13 lbs.
Phosphoric acid	15 lbs.
Other mineral substances.....	74 lbs.
	142 lbs.

Although 142 pounds of mineral substance may seem a small matter to take from a half acre of ground, it must be remembered that some of these ingredients exist in very small proportions in the soil, and only a small part of these may be in a soluble condition ready to be taken up by the moisture and given to the plant. Is there any means to supply this deficiency? Some improvement is generally made where clover is sowed, especially if the green crop is plowed in. The vegetable matter, even of the roots, tends to loosen the soil, and admit the air and moisture to bring a new quantity of phosphates, etc., into a soluble condition. Another plan, recommended for exhausted yellow soil of the upland, is to sow a crop of rye in the fall, clover in the spring, and turn in a drove of hogs in September for pasture. The rye will seed itself for the second year, when the hogs should be turned in again. Plowing in green manure and pasturing the ground are alike insufficient to add any mineral substance to the soil, and the most natural remedy is to use some fertilizer which will replace the elements removed. Stable manure is highly prized, and should be carefully husbanded; such a rotation is recommended that part of the farm be occupied by corn or wheat each year, and that these crops receive the manure. Rotten straw has been plowed under with satisfactory results. I am told that the improvement could be observed eight or ten years afterwards. Other fertilizers are needed to restore what is sold from the farm, and actual experiment alone will determine

what is best adapted to the several conditions. A few experiments have been tried with lime, plaster of Paris, and other artificial fertilizers, but as a record has seldom been kept of the actual cost and of the probable improvement by increasing the crops, a great difference of opinion exists concerning the practical money result. A farmer's deliberate opinions deserves all due respect, but a strong prejudice seems to prevail among some who have never tried any fertilizer, that just as long as they can clear a margin beyond their expenses, the use of artificial manures is throwing money away.

Many farmers have told me that they see the increased growth of weeds or grass near a limekiln, or where a log-heap was burnt. This observation is insufficient, however, to *prove* the value of *lime*, since the improvement may be due to the lime, or to the ashes which are rich in potash, and are known to be beneficial. A few farmers have applied lime to the soil, and generally have expressed themselves well pleased with the result; but an excess is injurious. One farmer tried twenty to twenty-five bushels to the acre with no apparent benefit. Although limestone abounds in the underlying beds, this does not crop out on all parts of the surface, and even where it does the lime is more easily dissolved and seems to be more effective as a stimulant for the plant. A plan tried near Quercus Grove is to moisten the seed corn and roll it in a mixture of lime and tar. This process is believed to improve the growth of the corn, as well as to protect the seed from some of its insect enemies, and the expense is trifling.

Land plaster, or uncalcined ground gypsum, is advantageous, especially for clover, and through this crop it benefits those which follow it.

An artificial fertilizer containing phosphate of lime has been tried with success in Dearborn county, but it should be used with moderation; an excess destroyed a crop of corn.

The remarks on fertilizers apply especially to the uplands, but similar needs exist in the high terraces of both rivers and creeks. Deep plowing, or even trench plowing, is

recommended here to bring up a subsoil that will easily become fertile by exposure. On the upland flats this is not practicable, because the subsoil, if brought to the surface, is not fitted to produce good crops without years of weathering. It is very possible that plowing one or two inches deeper than has been customary would not injure the surface soil, but would improve it by adding a new supply of potash, phosphates, etc. If barnyard manure or a crop of green clover is plowed under at the same time, it would be a great help in mellowing the stiff clay. After a few years the plow might be put still deeper, thus taking advantage of such resources as have been lying idle, though close at hand. It is probable that this land would be improved by *subsoiling*, or loosening the subsoil to a depth of a foot or more, without bringing it to the surface.

The flats are much improved by drainage. The commonest and cheapest way to effect this is to leave an open furrow at every two or three rods. This will only carry off the surface water, and the furrows require constant attention, besides occupying a considerable part of the land. Another plan is to lay poles in trenches, and cover them with earth. These make a sufficient outlet for water and do good service. The best and most satisfactory method is to lay drain tile. Mr. U. H. Stow, near East Enterprise, has tested the value of underdrainage on crawfish land, though the cost of bringing the tiles from Jefferson county adds materially to the expense. Mr. Stow says that drains three feet deep and six rods apart will be a great benefit. Apple trees, when drained, do not fail to produce good crops, and grapes send out their roots for rods, following the moisture.

Though the hillsides can be used indefinitely without fertilizers, they are liable to be injured by washing. Care must be taken on this account not to raise corn too long on broken ground, without a proper rotation of small grains or hay to allow the vegetable matter to accumulate. Pastures should not be cropped so close as to leave the ground bare, for when the gulleys take possession of the land it is a very expensive matter to reclaim it. The use of the "hillside

plow" is also strongly recommended, for if the field is plowed "round and round," part of each furrow will be up and down hill, and help the rains to carry off the soil.

The effect of shade, as a means of restoration, is illustrated on the farm of Mr. Givens, near Florence. A stony point, on which no soil had accumulated for several years, was covered with a pile of rubbish. When the evaporation of moisture was thus arrested, some blue grass seed that had lodged there germinated, and soon the plant was established. In three years the ground was well set with a natural growth of blue grass, and a soil had accumulated that could not easily wash off.

If a piece of clay is kneaded in the fingers, and placed in the sun to dry, it becomes hard. The same condition is seen in the surface of a road, when the mud has been worked by wheels and then dries. If clay soil is plowed while wet, a similar change takes place, it "bakes" and the roots can not so easily penetrate; if seed has recently been sown, the tender shoot has a hard crust overhead between it and daylight. The tramping of hoofs is apt to produce the same result, and the best farmers will not pasture a meadow from which they expect to cut a crop of hay.

The loss of river property by the wearing away of the bank is so serious as to demand prompt action. Paving and riprap are confined to the towns, on account of the expense. Brushwood, thrown over the bank and weighted down with stones, does good service in breaking the force of the waves and current when the river is high. The best means of meeting the difficulty is to encourage the growth of willows and other trees on the slope: Much injury has been done by clearing the native timber close to the water's edge. Willows grow readily on any part of the shore that is not too stony, provided that they can be protected from the cattle for three years. It is difficult for individual farmers to fence out the stock, as the water would wash away the fences required at a low stage. If cattle were kept away entirely, either by law or by mutual agreement, willows would quickly spring up in many places where they are now kept down by

the browsing of cattle. Willows have been planted out at various points with very satisfactory results. Mr. George Hickman, above Florence, recommends that some elms be set out with the willows. The willow cuttings should be put in as early as possible, as the winter or spring flood goes down, that they may be well rooted before the summer drouth. When the willows are cut off, they quickly grow up, and Mr. Golay, near Vevay, finds that he can use one-third of the crop each year for baling hay, without interfering with the primary object of the trees.

A rill flowing over the edge of a high terrace, as that below Vevay, very easily washes the loose gravel so as to do much damage in a single season. Care should be taken to control the drainage so that the water will have as little erosive force as possible. This is accomplished by conducting the stream away from the bank and down a gradual slope, or by putting in a trough to convey the water beyond the gravel bank.

EXPERIMENTS.

Now to my friends who are engaged in agriculture, allow me to express the wish that you may adopt such plans as will make the occupation profitable, and not only so, but that it may pay you the richest rewards of which it is capable. You desire to realize the largest possible profits, with the least necessary expenditure. But if a farm nets \$10.00 per acre when a profit of \$20.00 or \$30.00 is within reach, is not this poor management? It would be bad financiering to lend money at 6 per cent. when 8 per cent. can be obtained with good security. You have learned the importance of using the most improved implements, is it not equally essential to adopt the very best system of rotation, management and use of manures? Be assured of this that *it will pay* to adopt the very best methods, since the best methods are those which in the long run make the best returns; but many questions, yet to be decided, are included in this, what are the best methods? Our knowledge of botany and chemistry is founded on experiment and

observation. If agriculture is to maintain its ground with the advancing sciences, this also must be aided by judicious experiments. The more care is needed in this case, since we have to deal with the varying conditions of soil, location and climate; while proximity to market and the capital that can be invested will affect the practical results.. While experimental stations are established at various agricultural colleges, to do this work with great accuracy, some simple experiments may be conducted here, to elicit new facts for the benefit of these regions of drift and blue limestone. These may be conducted by individuals or through the agricultural societies. To be of value they must be planned to determine but *one thing at a time*. For instance, if it is desired to know whether the wheat crop on a certain kind of land would be benefitted by the use of lime, select a field as nearly uniform as possible, sow a certain quantity of lime, as ten or twenty bushels per acre, on one-half the ground, sow the grain evenly over the whole field, and treat both parts exactly alike. After the harvest, measure and weigh the wheat from each part of the field, and see which has been the most productive. If there is any difference in favor of the lime, calculate from the ruling price of wheat, the net proceeds for this year of the money invested in lime. The experiment is not yet complete, for the lime is not exhausted in a single year. Whatever rotation is adopted, keep watch of that field, and record the results from year to year; note how long the benefit of the lime can be observed. In practice, it may be better to add a small quantity of lime year by year.

It is with no thought of slighting the labors of those farmers who have tried experiments that I make these suggestions for more accurate investigations. Something has already been done, but it is only by such patient and accurate work that you can satisfy yourselves *how much* benefit you can expect from any plans that may be recommended. By patient, laborious experiments alone, can we hope to reach anything like true scientific agriculture. Although the trouble and expense of working by weight

and measure may not be rewarded by a proportionate increase of the crop in every instance, yet this is our means of studying nature. Even as an intellectual occupation, this is delightful; how much more when you may hope to realize new truths that will benefit the whole community, and you are studying the operations of Him who "gave us rain from heaven and fruitful seasons, filling our hearts with food and gladness."

ACKNOWLEDGEMENTS.

I can not close this report without returning my sincere thanks to all who have kindly given their aid in the labor of collecting the facts now presented to the public.

Besides the favors received from those whose names occur in the body of the report, I am indebted to the officers of each county for the use of maps and other information; to President Martin, of Mooreshill College, for access to the cabinet; to Messrs. G. W. Morse and T. E. Alden, of Rising Sun, for special favors; to Dr. Sale, of Dillsborough, Mr. B. North, of Ohio county, Messrs. John Gill, John Shroder and Armstrong, of Vevay, and very many others.

To Dr. G. Sutton, of Aurora, and Mr. C. G. Boerner, of Vevay, I am indebted for many kind favors, besides their additions to the report, which will be found in another part of this volume.

VEVAY, INDIANA, Nov., 21, 1872.

DEAR SIR—I have the honor to transmit to you a paper on the meteorology of Switzerland county, Indiana, prepared by me at the request of your assistant Prof. R. B. Warder, while engaged in the geological survey of this county last summer. From the limited time he allowed me, I have not been able to make the report as full as I wished, however I have carefully prepared a set of tables on the Barometer, temperature, rain and snow, which I have no doubt will prove of general interest in connection with the geological survey.

I have been obliged to omit the tables of Psychrometer, clouds, wind and velocity; these subjects may, however, be deferred for a future time and afford interesting material for a supplement.

I remain with the highest regard,

Your obedient servant,

CHARLES G. BOERNER.

Prof. E. T. Cox, State Geologist.

METEOROLOGY

OF

VEVAY, SWITZERLAND CO., IND.,

BY CHARLES G. BOERNER.

A knowledge of the climate and the laws which govern it, is not only essential, but absolutely indispensable to the welfare of a nation or community. The intelligent agriculturist will not only examine into the chemical and geological components of the soil, but also study the temperature, wind and moisture, which, according to circumstances, may be either beneficial or injurious to his productions and health.

It is alone, by becoming familiar with the principles of practical agriculture, chemistry of the soil, geology and meteorology, that the material and intellectual interests of both farmer and mechanic are advanced, the resources of the soil and the mines developed, which, in connection with commerce and manufactures, lay the foundation of a nation's wealth.

The climate of this county does not differ materially from the adjoining counties, but that there are changes peculiar to each, of temperature and moisture, is evident from observations at points above and below, on the shores of the Ohio river.

It would be mere conjecture to account for these local variations, or their controlling influence; comparison, guided by established facts in meteorology can alone afford us light.

Whether the climate has undergone any striking changes since its first settlement in 1803 can not be ascertained, as there is no record of remote date in existence. During the year 1818, and later, a meteorological register was kept by Mr. John J. Dufour, one of the early settlers, which consisted of temperature, rain and wind. Unfortunately his records are lost, but I am in possession of a copy of the "Indiana Register," of January 27th, 1818, (a weekly paper then published at Vevay) which contains a summary of his observations of the previous week, viz: January 20th, to the 26th.

While no great importance can be attached to the results of a single week in our changable climate, it may be of interest to take a look back fifty-four years, and for sake of comparison I have introduced them with observations of the corresponding weeks of the years 1865 to 1872, and which form the subject of table I.

Mr. Dufour's observations were taken at 6 A. M. and 2 P. M.; those by myself at 7 A. M. and 2 P. M., with the daily means resulting from three observations (omitting the 9. P. M.)

Systematic registry of meteorological phenomena was commenced by myself in 1864, in accordance with the plan adopted by the Smithsonian Institution, at 7 A. M. 2 P. M. and 9 P. M.

The instruments are the Smithsonian standard, made by James Green, of New York, and consist of cistern barometer, psychrometer, thermometer, wind and rain gauge.

The geographical position of Vevay, county seat of

Switzerland, Indiana, is latitude north $38^{\circ} 46'$, longitude west of Greenwich, $84^{\circ} 59' 20''.5$; hight above the level of the sea 525 feet, and above low watermark, in the Ohio river, 81 feet.

The range of the thermometer, for the past eight years, is equal to one hundred and ten degrees (110°) from -10° to 100° , and from its variability throughout the year, sometimes experiences the cold of Minnesota and the heat of Florida.

Our prevailing winds are from the southwest. The most striking characteristics on the bottom lands along the river are the frequent and dense fogs with which the hill lands are rarely ever effected. The tables are arranged in the following order:

TABLE I.—Comparison of observations January 20th to 26th, 1818, with the corresponding week of the years 1865 to 1872.

TABLE II.—Maximum and minimum pressure of the barometer, reduced to temperature 32° Fahr.

TABLE III.—Monthly and annual mean hight of the barometer, corrected for temperature.

TABLE IV.—Maximum and minimum temperature of each month for a series of eight years.

TABLE V.—Monthly and annual mean of temperature.

TABLE VI.—Mean temperature of the four seasons—spring, summer, autumn, winter.

TABLE VII.—Monthly and annual quantity of rain and melted snow, in inches and hundredths.

TABLE VIII.—Monthly and annual quantity of snow in inches and hundredths.

The length of our winters becomes more apparent in the early and late flowering of plants in the open air. For instance, the "Crocus," first of all to expand with the genial rays of the sun, though snow may cover the ground; its appearance is a pretty sure indication of an early or late spring. For comparison, the time of blooming in the open

air, in the same location, is here given for a period of seven years:

1866	-	-	-	-	-	March 5th.
1867	-	-	-	-	-	February 26th.
1868	-	-	-	-	-	March 6th.
1869	-	-	-	-	-	February 20th.
1870	-	-	-	-	-	March 19th.
1871	-	-	-	-	-	February 25th.
1872	-	-	-	-	-	March 18th.

Thus it will be seen that the earliest blooming occurred in 1869, and the latest in 1870; and that 1870 and 1872 show a difference of only one day, the two extremes about four weeks.

TABLE I.

Comparison of Thermometer, January, 1818 and 1865 to 1872.

January.	1818.				1865.				1866.				1867.				1868.			
	6 A. M.	2 P. M.	Mean.		7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.
20	42.	46.	44.0	°	30.	36.	28.0	28.3	15.	20.	17.5	15.0	22.	28.	25.0	25.3	33.	37.	35.0	34.3
21	44.	55.	49.5	°	36.	40.	38.0	37.3	8.	25.	14.5	17.6	22.	24.	23.0	22.6	37.	38.	37.5	35.3
22	40.	50.	45.0	°	36.	40.	38.0	36.6	25.	36.	30.5	30.3	21.	31.	24.0	24.0	22.	42.	32.0	34.6
23	30.	40.	35.0	°	28.	27.	27.5	25.0	30.	36.	33.0	32.6	22.	28.	25.0	23.0	40.	47.	43.5	41.6
24	40.	55.	47.5	°	16.	22.	19.0	16.0	34.	36.	35.0	34.6	24.	26.	25.0	26.0	22.	30.	27.5	23.6
25	30.	44.	37.0	°	5.	22.	13.5	15.0	32.	35.	33.5	33.0	30.	18.	39.0	33.3	15.	45.	30.0	32.0
26	44.	42.	43.0	°	10.	20.	15.0	13.3	31.	40.	35.5	34.3	22.	26.	24.0	22.6	38.	47.	42.5	41.6
Mean.	38.6	47.4	43.0		21.6	29.6	25.6	24.5	25.0	32.6	28.5	28.2	23.3	30.1	26.4	25.3	29.6	40.9	35.4	34.7

TABLE I.—Continued.

	1869.				1870.				1871.				1872.			
	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.	7 A. M.	2 P. M.	Mean.	Mean of 3 obs.
January 20.....	33.	45.	39.0	36.0	25.	46.	35.5	35.0	30.	44.	37.0	38.3	36.	35.	35.5	34.3
January 21.....	27.	45.	34.0	36.3	27.	43.	35.0	34.2	31.	49.	40.0	42.2	28.	30.	29.0	38.3
January 22.....	34.	43.	38.5	32.0	33.	56.	44.5	48.0	28.	35.	31.5	31.5	29.	43.	34.0	36.7
January 23.....	24.	45.	34.5	33.5	52.	43.	47.5	45.3	30.	46.	38.0	36.5	30.	23.	26.5	24.7
January 24.....	31.	54.	42.5	42.3	35.	33.	34.0	33.7	30.	36.	33.0	31.7	10.	19.	15.5	14.7
January 25.....	31.	31.	31.0	28.3	33.	44.	38.5	39.3	28.	30.	29.0	28.8	10.	22.	16.0	16.0
January 26.....	15.	40.	27.5	26.0	32.	58.	45.0	44.3	30.	27.	28.5	27.5	18.	29.	23.5	25.0
Mean	27.9	49.3	35.3	33.5	33.9	46.1	40.0	35.7	29.6	36.7	33.9	33.6	23.0	28.7	25.7	25.7

TABLE No. II.

Barometer Reduced to 32° Fahrenheit.

YEAR.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.	In.	Io.
1867 .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1868	30.10	29.18	30.11	29.32	29.88	28.76	29.76	28.53	29.00	29.06	29.60	29.15	29.45	29.03	29.52	29.10	29.65	29.15	29.85	29.16	29.76	29.17	29.35	29.05
1869	29.57	29.10	29.76	28.80	29.82	29.07	28.84	29.72	29.03	29.63	29.86	29.18	29.84	29.46	29.87	29.00	29.69	29.42	30.03	29.26	29.04	28.77	30.03	29.15
1870	30.05	28.92	29.88	28.73	29.96	28.51	29.76	29.14	29.08	28.90	29.74	29.13	29.68	29.21	29.74	29.31	29.74	29.28	29.90	28.95	29.96	29.10	30.08	28.86
1871	29.36	29.15	29.97	28.74	29.79	29.05	29.93	29.01	29.09	29.16	29.63	29.16	29.71	29.22	29.68	29.19	30.01	29.30	29.88	29.27	29.93	28.86	30.09	29.07
1872	29.20	29.04	30.05	29.01	30.00	28.82	29.85	28.06	29.53	28.88	29.38	29.18	29.65	29.25	29.77	29.32	29.50	29.03	29.84	29.24	.....	.....	.....	.....
Mean .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	29.30	29.09	29.95	28.92	29.89	28.84	29.70	28.68	29.70	28.99	29.31	29.16	29.66	29.25	29.72	29.28	29.77	29.25	29.90	29.17	29.91	29.02	29.99	29.06

TABLE NO. III.
Mean Elevation of the Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1867.....	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1868.....	29.29	29.08	29.49	29.46	29.30	29.38	29.24	29.33	29.33	29.48	29.53	29.57	29.575
1869.....	29.41	29.35	29.41	29.31	29.39	29.62	29.01	29.07	29.74	29.01	29.43	29.48	29.406
1870.....	29.54	29.43	29.46	29.47	29.43	29.45	29.47	29.48	29.54	29.55	29.55	29.66	29.598
1871.....	29.03	29.49	29.42	29.35	29.16	29.43	29.47	29.44	29.60	29.58	29.53	29.63	29.494
1872.....	29.59	29.46	29.53	29.50	29.48	29.48	29.47	29.52	29.50	29.61	.....	.....	29.501
Mean	29.49	29.45	29.46	29.42	29.41	29.47	29.45	29.49	29.54	29.57	29.55	29.58	29.493

TABLE No. IV.

Maximum and Minimum Temperature of each Month during a series of Eight Years.

YEAR.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1865	45.0	-2.0	63.0	14.0	78.5	16.0	82.0	34.0	89.0	42.0	95.0	65.0	100.0	60.0	95.0	58.0	99.0	51.0	96.0	37.0	78.0	24.0	76.0	6.0
1866	69.0	44.0	70.0	-7.0	76.0	18.0	97.0	23.0	98.0	46.0	99.0	50.0	100.0	67.0	96.0	50.0	90.0	50.0	82.0	32.0	64.0	27.0	60.0	5.0
1867	57.0	0.0	62.0	-10.0	61.0	11.0	83.0	31.0	92.0	35.0	99.0	60.0	100.0	68.0	98.0	52.0	97.0	42.0	90.0	28.0	77.0	10.0	72.0	11.0
1868	60.0	0.0	61.0	45.0	82.0	10.0	85.0	23.0	95.0	50.0	95.0	60.0	99.0	73.0	90.0	58.0	86.0	44.0	80.0	30.0	68.0	28.0	57.0	-2.0
1869	61.0	15.0	70.0	13.0	71.0	6.0	76.0	30.0	84.0	43.0	90.0	51.0	93.0	60.0	95.0	57.0	88.0	42.0	77.0	21.0	61.0	21.0	51.0	18.9
1870	58.0	5.0	58.0	1.5	62.0	15.5	85.5	31.0	90.0	46.0	94.5	56.0	93.0	60.5	94.0	58.5	90.0	53.0	79.5	39.0	73.5	24.0	61.0	-4.0
1871	65.5	13.5	67.0	20.5	78.0	30.0	82.0	32.0	88.0	44.0	91.5	61.0	97.0	58.0	96.0	56.0	88.0	37.0	84.0	32.0	72.0	13.0	64.0	-7.0
1872	47.0	2.0	58.0	5.0	69.0	10.0	85.5	32.0	86.0	46.5	89.0	59.0	92.0	65.0	96.0	53.5	93.5	45.0	87.0	30.0	.....	.....	.....	.....
Mean...	60.31	4.69	63.63	5.25	72.19	14.56	84.50	30.75	90.63	44.06	94.13	57.50	96.75	63.94	95.00	55.38	91.06	45.50	84.44	31.13	70.60	18.38	55.13	3.38

From November to December, the average is for seven years

TABLE No. V.
Monthly and Annual Means of Temperature.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1865	25.8	37.4	43.7	56.4	64.4	77.5	77.8	74.8	77.2	65.0	44.1	36.7	56.33
1866	32.3	33.6	42.1	61.8	64.4	77.8	84.7	75.9	68.9	58.9	45.3	31.9	56.46
1867	24.7	41.7	38.6	55.7	61.4	79.6	80.3	80.3	74.0	67.9	47.0	34.9	56.33
1868	29.2	33.7	50.3	53.1	67.6	76.9	84.8	76.3	66.8	54.9	44.1	30.1	55.56
1869	31.1	38.0	37.9	51.3	61.2	69.9	75.8	76.6	66.6	46.6	39.6	35.7	52.52
1870	34.7	34.4	39.1	55.4	66.8	72.8	77.9	76.4	71.4	58.1	44.9	32.1	53.26
1871	26.5	37.7	50.3	59.8	66.0	74.9	75.2	77.4	64.8	57.5	42.1	36.5	53.89
1872	28.9	33.2	37.1	57.4	66.8	72.5	77.2	76.2	68.0	54.3	.....	.....	.....
Mean	30.27	36.21	43.01	56.24	64.82	75.25	79.21	76.60	68.59	56.39	43.57	33.13	56.68

TABLE No. VI.

Mean Temperature of the Four Seasons.

YEAR.	SPRING.	SUMMER.	AUTUMN.	WINTER.
1865	66.13	76.60	45.27	37.39
1866	68.00	76.50	45.37	36.00
1867	65.57	78.17	46.60	35.00
1868	65.87	75.63	43.03	37.73
1869	60.80	73.00	40.60	35.67
1870	65.00	74.90	45.03	36.07
1871	66.57	72.47	43.37	41.17
1872	65.57	73.80	.....	33.07
Mean	65.44	75.19	44.18	36.50

TABLE No. VII.
Monthly and Annual quantity of Rain and Melted Snow in Inches and Hundredths.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Amount.
1865	4.70	0.63	2.70	6.73	11.80	2.45	4.70	1.98	6.61	1.55	1.25	6.70	50.69
1866	3.95	1.84	5.72	1.69	1.50	5.28	6.95	1.47	15.25	1.48	4.23	3.09	52.44
1867	6.13	7.24	5.52	1.70	4.25	2.20	3.95	4.09	0.77	1.64	3.50	6.40	48.54
1868	6.30	0.90	5.40	3.65	5.93	4.95	1.17	4.29	6.72	1.30	1.72	2.82	45.05
1869	1.87	4.05	5.40	3.94	5.95	4.54	0.90	2.10	3.05	2.97	4.74	3.47	42.98
1870	7.13	2.47	3.93	2.37	2.37	3.40	3.20	2.55	1.20	2.43	1.50	2.13	35.13
1871	2.52	4.29	4.74	2.77	3.16	2.30	3.52	4.06	0.47	1.00	3.07	3.75	36.05
1872	0.75	2.22	1.04	7.13	4.15	6.67	5.16	3.55	3.17	4.05	.....	.....	37.94
Mean	4.17	2.96	4.31	3.63	4.99	4.15	3.73	3.01	4.64	2.95	2.86	4.05	43.80

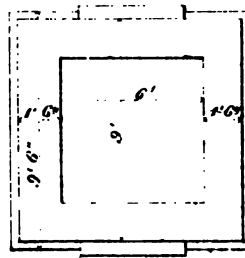
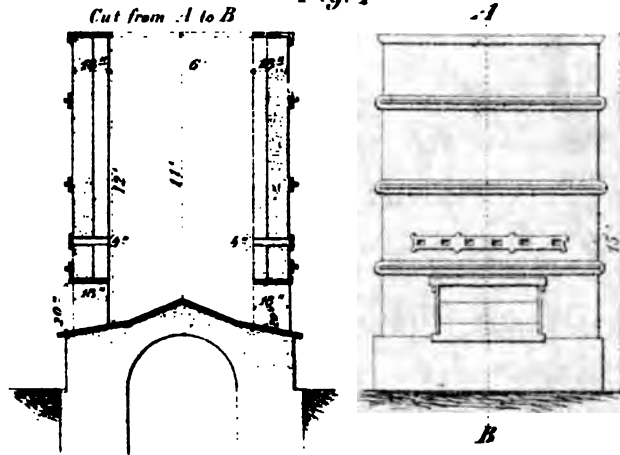
TABLE No. VIII.
Monthly and Annual Quantity of Snow in Inches and Hundredths.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual amount.
1865	31.00	2.10											33.10
1866	1.10	0.10		2.00								1.88	5.13
1867	19.20	11.75	9.00									20.25	39.95
1868	9.00	1.00	0.50	3.00							0.05	2.35	15.90
1869	2.00	1.30	0.90	0.10						2.00	3.35	6.75	16.40
1870	5.35	7.75	1.75								9.00		23.85
1871	6.90	0.25									0.15		11.99
1872	4.95	9.00	0.20								6.60		14.15
Mean	9.81	4.16	1.54	0.64						0.25	1.44	4.60	19.92

Through the kindness of my friend, Prof. J. W. Foster, LL. D., of Chicago, I have secured the privilege of publishing a highly valuable paper, on the manufacture of Spiegeleisen, from the pen of Hugh Hartmann, Ph. D., C. E., a graduate of the Polytechnical Academy of Berlin, late assistant in the Spiegeleisen Works of Hannover, Prussia, and now residing at Omaha, Nebraska.

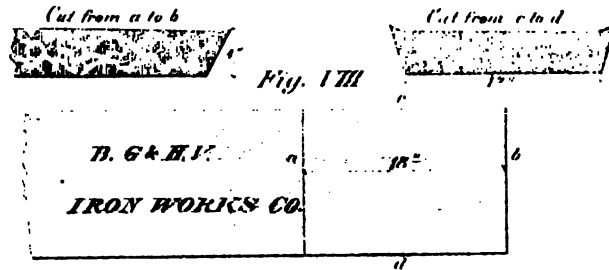
E. T. COX,
State Geologist.

Fig. I



Scale of Fig. I: 1" = 6'

Fig. VIII



MANUFACTURE OF

Spiegeleisen, Specular or Glittering Iron,

BY HUGH HARTMANN.

Prof. J. W. Foster of Chicago, in his prominent and attractive letters on the new era "dawning upon the great industrial resources and mineral wealth" of the State of Indiana, (first published in the New York Tribune, and afterward brought together in a compact form, in compliance with a generally expressed wish), gives, especially in his letter on "American Bessemer Steel Rails," dated Chicago, 11th March, 1872, an explanation of the Bessemer process of steel making.

In this short but very comprehensive description of the "simple process," Prof. Foster says that the 10 or 15 per cent of Spiegeleisen which is allowed to flow into the mass of decarbonized iron in the "Convertor," is, up to the present time, mostly manufactured in Germany, and brought from there to this country.

Having been employed in that country during a series of years with an Iron Works Company, especially producing

the above mentioned kind of iron, I shall try to give to the readers of Prof. Foster's letters an explanation of the manner in which the manufacturing of the Spiegeleisen is, at the present time, produced.

The Spiegeleisen, specular or glittering iron, a pig metal which breaks into more or less large mirror-like facets, was formerly produced by charcoal, out of manganiferous iron ores, its singular peculiarity being due to the presence of 10 to 12 per cent. of manganese, on which the Bessemer process depends for its success. The hot-blast furnaces were of small outlines, but always in splendid working condition. The stacks of the well-known Meisener Stahlberg Iron Works, and others in that vicinity, were built as follows:

Total hight of furnace.....	35 ft.	.....
Hight of tuyeres above bottom.....	1 ft.	3 in.
Hight of hearth.....	5 ft.	.....
Hight of boshes.....	9 ft.	5 in.
Diameter of tunnel head.....	3 ft.	.....
Diameter of boshes.....	9 ft.	.....
Diameter of upper part of hearth.....	2 ft.	8 in.
Diameter of lower part of hearth.....	1 ft.	11 in.

They were conducted with hot blast air of from about 300° to 480° F., the air forced into the furnace through two tuyeres of 2½ to 2¾ inches diameter, under a pressure of 1½ to 1¾ pounds per square inch. The average consumption of charcoal, per one hundred pounds pig metal, was about one hundred and eighteen to one hundred and twenty pounds; the average daily production during the year, nine thousand pounds, or four and a half tons. In the practical working of the furnace the spathic ores yielded about thirty-eight to forty per cent. of iron.

But, on account of the devastation of the forests and of the scarcity of hard wood suitable for conversion into good charcoal, this fuel, soon after the year 1859, proved insufficient for the large production of spiegeleisen wanted; therefore, they were compelled to make great efforts in replacing the charcoal by coke made from well prepared

bituminous coal, as a reducing agent, there not being in the iron manufacturing region a coal sufficiently free from sulphur and other deleterious materials to allow its use in a crude state. The spiegeleisen made with charcoal was a very valuable metal, due to the purity of the ores, entirely free from sulphur and phosphorus, and we all know that no metallurgic skill has thus far been able to expel these deleterious ingredients from any ores or coke, or prevent them from passing into the pig iron.

In Rhenish Prussia are some great and well conducted iron manufacturing establishments, (in the vicinity of Düsseldorf and Duisburg,) where, during the year 1860, the first trials were made of producing spiegeleisen with coke as the fuel. These first trials being a total failure, it is certainly a noteworthy fact that, nevertheless, the zeal of the iron-masters did not relax. On the contrary, the first, though a failure, was followed by a series of trials, and it is impossible to say how great and high a praise this persistence merits; but it required the skill of highly experienced men to solve the problem of this entirely new branch of work, while, at the present day, the fabrication of specular iron is common work to many well trained iron-masters. Having at last been successful, there are at the present time some eight or ten large blast furnaces, each producing daily some thirty tons of this valuable and peculiar pig metal.

In giving a detailed description of one of these establishments, I shall first speak of the iron ores, of which four different kinds are used.

First: Red Hematite, a very pure ore from the beds existing on the borders of the "Lahn," a larger tributary of the Rhine, in the province of Nassau. Of this ore there are two varieties; a harder and compact mineral associated with a calcareous gangue, and a softer and pulverulent hematite. Both varieties are entirely free from sulphur and phosphorous, containing from three to four cent. of manganese, a small per centage of alumina, water and silica. The presence of carbonate of lime in the body of the compact ore gives it a particular character and renders it eminently

fitted for mixing with other siliceous ores, there being in the ore fifty per cent. of iron and from ten to fifteen per cent. of carbonate of lime. This ore is highly esteemed for the reason that there is great economy in smelting, owing to the presence of a lime flux in its most favorable conditions. The soft pulverulent ore is richer, yielding fifty-five to fifty-eight per cent. of metallic iron in the practical working of the furnace. Both kinds are easily reduced.

Second: The products from decomposition of the specular ore—the German “Brauneisenstein”—of similar favorable constitution and equally free from obnoxious admixtures. It contains some water chemically combined ($2\text{Fe}_2\text{O}_3, 3.40$), is porous in structure, yields about fifty to fifty-four per cent of iron and is more easily reduced than any other ore.

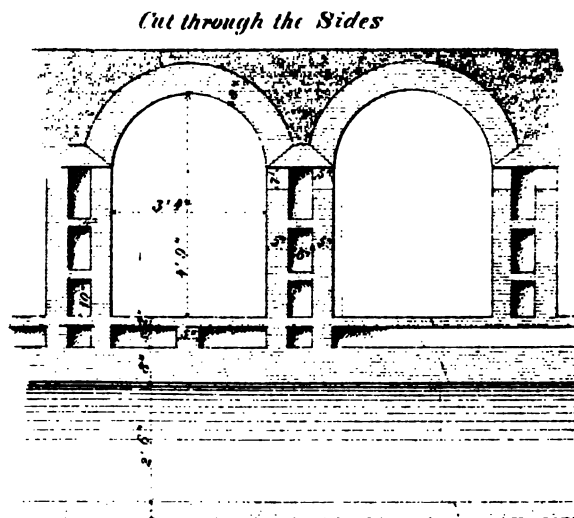
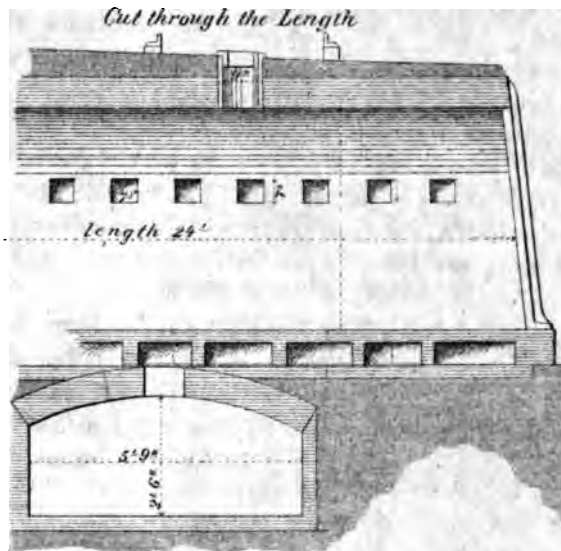
Third: Excellent spathic iron ore from the vicinity of Musen (Stahlberg), in which a certain proportional part of the iron—from eight to fourteen per cent.—is replaced by manganese.

More or less, all the spathic ores ($\text{Fe O}, \text{CO}_2$) contain a trace of sulphur, and afford therefor, and for expelling the carbonic acid gas, and the subsequent process of dispersion and decomposition of the formed sulphuric acid constitutes by means of the influence of the atmospheric moisture. The calcination takes place in kilns, for the outlines of which see Fig. 1, page 451. In these roasting furnaces, by distributing it in alternate layers with waste coal, the ore is rendered porous and easily broken into small pieces, whereby it is more readily acted upon in the smelting furnace. The chemical constitution of the ore in the crude state is, viz.:

$\text{MnO}, \text{CO}_2 + 4\text{FeO}, \text{CO}_2$	{	Oxide of iron, - -	49.01
		Oxide of manganese, -	12.43
		Carbonic acid, - -	38.56

The above oxide of iron equals 37.85 per cent. of metallic iron. The above ore is changed by the calcining process into Sesquioxide of iron, - - 81.89 = to 56.78 metallic iron. Sesquioxide of manganese, - 18.11.

Fig. II



Scale of Fig. II 1" = 4'

Fourth: An aluminous ore, used for admixture with the above named ores to make a slag of a good natured character; it contains some 20 per cent. of iron.

A glance at a map of the county will show that these deposits of ores, being only from 80 to 100 miles distant are as easily accessible by navigation as by rail; the cost of transportation by railroad estimated at four and two-tenths cents per ton per mile, these ores are delivered at the furnace, by rail, at five to six dollars per ton.

To convey the ores from Nassau to the iron manufacturing centre involves a navigation of seventy-five miles at a cost of \$1.20 per ton, in addition to dockage and transfer from the docks on the Rhine, making the entire cost of the ore (including the purchase money) \$3.40 cents per ton.

THE FLUXING AGENT.

The flux is a very pure carbonate of lime, obtained in the vicinity of the iron works, from the borders of a small creek, the Dussell, the constituents of which are:

Carbonate of lime,	-	-	-	-	98.00
Silica,	-	-	-	-	1.50
Hygroscopic water,	-	-	-	-	.50

OF THE FUEL.

As a reducing agent coke is used (as above mentioned), the bituminous coals being purified prior to their application to the blast furnace. The coals are from the vicinity of the iron works and the ores are brought thither, for it is always cheaper to bring the iron ores into union with the coals, than the coal into union with the ores. They contain a good deal of slate and from 5. to 1. per cent. of sulphur, and to eliminate these noxious adherents they are subjected to a very careful process of grinding (to the size of a hazel-nut,) and separating by means of water, there being a difference between the specific gravity of pure coal on the one hand, and the slate and sulphur on the other, viz.:

Specific gravity of the coal,	- -	1.21 to 1.51
Specific gravity of the slate,	- -	2.64 to 2.67
Specific gravity of the sulphur,	-	1.96 to 2.05

Having been subjected to this process the coals are coked in closed furnaces (Frangois' system, fig. 2, p. 455), the charge of each furnace consisting of 120 sheppel a' 1.7-9 cubic feet a' 92-100 lbs. (1 sheffel = 1.5-6 bushels) covering the bottom of the furnace to a height of 18-20 inches. The coking process lasts 36 hours, and furnishes from 57 to 60 per cent. of coke, by weight. of a porous, cellular character, sufficiently firm to hold up the burden of the furnace and containing 8 to 10 per cent. of ashes of a reddish white or gray color. The volatile carbonic matter of the coals, after having been used to heat the partitions and floors of the coking furnaces, are sufficient to heat the steam boilers.

OF THE STEAM ENGINES:

Which produce the blast air. There are two eighty horse power horizontal engines, manufactured by the magnificent Seraing Iron Works Company, Belgium, of the most elaborate character, maintaining four blast furnaces; and one vertical one hundred horse power engine for a fifth furnace, and for reserve.

To regulate the movement of the blast-air, it passes next to a reservoir two hundred feet long, and six feet in diameter, and equal to five thousand six hundred and fifty-four cubic feet.

The principal dimensions of the horizontal engines are as follows:

Diameter of steam cylinder.....	3 ft. 3 in.
Diameter of blast-air cylinder.....	7 ft. 6 in.
Length of steam cylinder.....	6 ft. 0 in.

Producing, therefore, during each revolution of the fly-wheel, one thousand and sixty cubic feet, or by eighteen or nineteen revolutions per minute, eighteen thousand cubic feet, and with a loss by leakage, of twelve per cent., sixteen thousand eight hundred cubic feet.

The vertical engine has the same diameter of the steam cylinder as the foregoing, three feet, three inches.

Length of cylinder..... 7 ft. 9 in.

Diameter of blast-air cylinder..... 8 ft. 0 in.

By thirteen revolutions per minute, there will be eighteen thousand cubic feet of blast air, less ten per cent. for leakage.

Before being forced into the furnace, the blast-air is heated by means of the gases escaping from the mouth of the furnace and collected there by means of an apparatus described in another place. Two heating apparatus of the shape like figure 3, page 460, are sufficient to heat the blast-air of each furnace.

Fifth: The outlines of the Blast Furnaces (figure 4, page 465) are as follows, there being two groups of stacks constituted after the shape of No. 1, and No. 2:

	No. 1.		No. 2.	
	FT.	IN.	FT.	IN.
Height of furnace.....	54	.....	54	.....
Diameter of tunnel head.....	8	8	9	6
Diameter of boshes.....	15	2	15	3½
Diameter of hearth, (upper end).....	4	9	3	11½
Diameter of hearth, (lower end).....	4	9	2	10
Height of hearth.....	6	3	7	9½
Height of boshes.....	11	9	10	9½
Height of center of tuyeres above the bottom.....	2	5	2	5
Inclination of the boshes, fifty degrees.....				
Square contents of the mouth.....	59	.....	72	.....
Square contents of the boshes.....	180	.....	183	.....
Cubic contents of the whole furnace.....	6396	.....	5910	.....

The bottom and lower part of the hearth, as high as three feet above the tuyeres, are built with "Puddingstone," a coarse grained siliceous sandstone from Marchin, near Huy, Belgium, in the province of "des Andennes," a very excel-

lent and durable material, and the upper hearth, boshes and tunnel of the furnace with bricks formed out of the excellent fire clay from Andennes, Belgium.

The business of iron-producing is managed in the following manner. It must be previously borne in mind, and anxiously considered—this having been the problem which caused so much trouble and meditation to the iron-masters—that the spiegeleisen is chemically composed of four parts of iron and one of carbon (Fe. 4, C.), and that the combination is only formed during the period of the smelting process, which follows immediately after the deoxidation of the iron ores.

To fulfill the conditions under which this combination of iron and carbonic matter can take place it is absolutely necessary that the mixture of ores and flux be of the most fusible nature, so as to allow of the accumulation of the charge—in proportion to a fixed amount of coke—to such a degree, that the smelting and the separation of the iron from the slag occurs at a point as near as possible to the tuyeres. It is safe to say that this separation, when resulting at a higher place in the hearth would give too great an opportunity for the carbonic acid gas (Co. 2) to carry off some of the carbonic matter from the iron, changing itself into C. O. and reducing, at the same time, the constitution of the Spiegeleisen (Fe. 4, C.) to a lower grade of carbonization. The temperature at which the specular iron melts is the same as that at which its constitution is formed and is calculated to = 3582° Fahr.

It was therefore found necessary that the charges should be composed as follows:

- 30 per cent. red hematite.
- 38 per cent. spathic ore.
- 20 per cent. decomposed brown ore.
- 12 per cent. aluminous ore.

Yielding 40 to 50 per cent. metallic iron in the practical working of the blast furnace and to create the needed fusible slag there was added from 32 to 40 per cent of lime.

Each charge consisting of

1860 lbs. coke (according to six small wagons of three hundred and ten lbs. each.)

2800 to 3200 lbs. mixed ore.

800 to 960 lbs. carbonate of lime.

The furnace affording thirty-five to forty charges every twenty-four hours, and yielding an average of 60,000 pounds or thirty tons per day.

For a ton (2,000 lbs.) of pig metal, were consumed.

Iron ore, 4,000 lbs. = 50 per cent.

Lime, 1280 lbs. = 32 per cent. fluxing agent, yielding 37 to 87 per cent.

Coke, 2480 lbs.

The ashes of the coke are always found to represent in their chemical constitution the proportion of the

Oxygen of the acids, 2:

Oxygen of the bases 1:

Even together with a part of 3:1, while the oxygen of the constituents of the always is of slag the proportion O. of B. 1: But it would be of the slightest influence to give the ashes a proportional admixture of flux (lime) because they will melt only at the nearest point to the tuyeres, or the *furnace* where the whole process of smelting takes place, which if brought into calculation to join the ashes will always enter the slag formed by the other earthen materials accompanying the iron.

Nevertheless, it is absolutely necessary to accumulate so much of the lime in the slag, that the same will be of a caustic character, dismembering under the influence of the atmospheric moisture.

Slags resulting from many different kinds of chemical constitution (of different ores) will always admit more carbonate of lime than it seems to be possible considering their chemical constitution.

The blast air, with a temperature of from 630° to 660° Fahr. averaging above the melting point of lead, is forced into the furnace under a pressure of $2\frac{1}{2}$ to 3 lbs. per square inch at the engine, and of 2.2 to 2.6 at the tuyeres.

Out of the five tuyeres two are on opposite sides and one at the rear of the furnace, each one declined a few degrees from the center of the hearth so as to force the blast-air into

a kind of whirlwind (fig. 5, page 465) which is considered the best way of distributing the compressed air through the smelting and combustible mass.

The diameter of the mouth of the nose-pipes varies from 2 to 3½ inches, according to the working condition of the furnace; each increase or diminution is made with one sixteenth of an inch. The nose-pipes are constructed in a manner so as to close the tuyers preventing the escaping or rebounding of the blast-air. (fig. 6, page 465.)

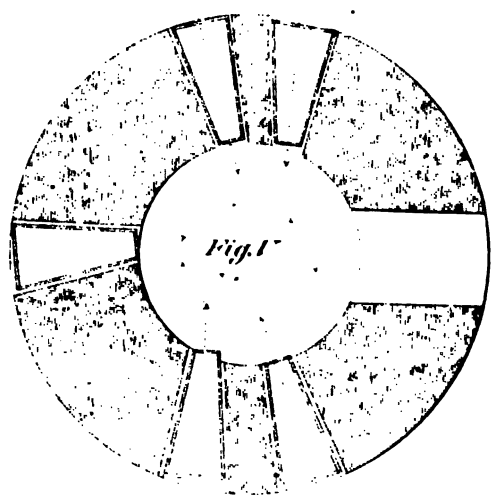
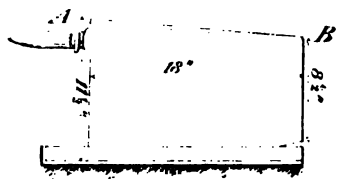
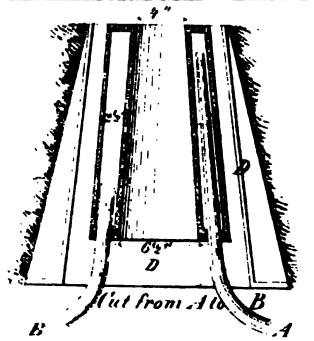
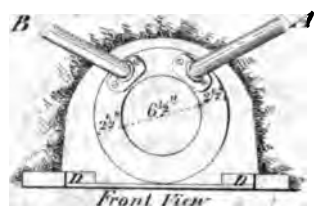
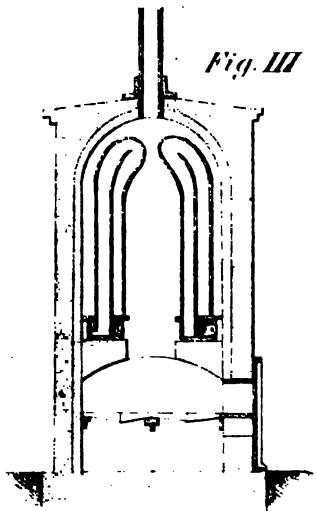
Owing to the high temperature in the hearth, the tuyers, and even the mass of stone forming the hearth, would not endure for any length of time, but being provided with a circulation of water (fig. 7, page 470) they last two or three years and over.

The signs of a good working condition of the blast furnace are, to an experienced eye, the following: The slag is nearly stony, showing a superamount of lime, only the edge being somewhat glassy, the color of the interior stony part is a light green or greenish yellow, covered on the outside with a thin brown coat; the slag flows steadily and easily over the sandstone, even to a considerable distance, proving thereby not only its own fluidity and warmth but also the existence of the desired and necessary heat in the hearth of the furnace.

The furnace is tapped every eight hours and the fore part of the hearth, as far as the tuyeres, is cleaned once during the time. The tuyeres are always clear and bright and very seldom need a mechanical cleaning, the flame escaping from the tunnel head of the furnace is without any smoke, not very hot and of a light reddish-blue color, (a hot, red flame indicating a change in the working of the furnace.) If the mouth of the furnace is closed by means of an apparatus to prevent the gases from escaping, so as to use them for heating the blast-air, they never show a temperature greater than between 140° and 176° Fahr.

The metallic iron runs into large channels formed in sand, which are covered as soon as possible with a layer of dry sand to retard its cooling, thereby producing facets of a

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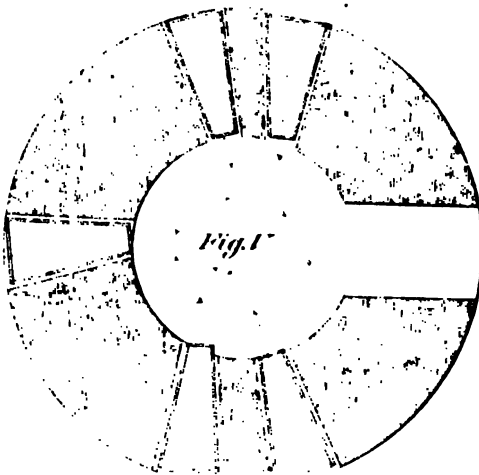
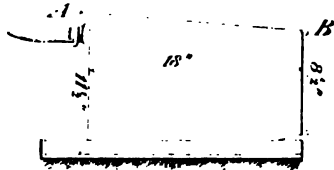
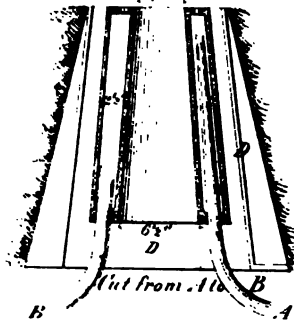
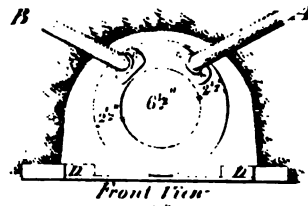
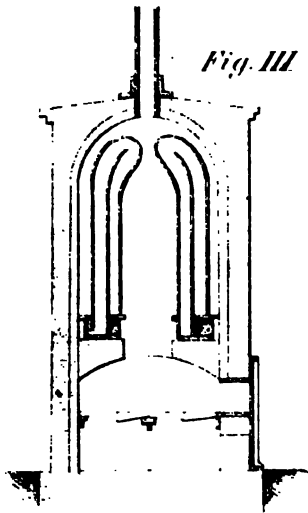
Owing to the high temperature in the hearth, the tuyers, and even the mass of stone forming the hearth, would not endure for any length of time, but being provided with a circulation of water (fig. 7, page 470) they last two or three years and over.

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The metallic iron runs into large channels formed in sand, which are covered as soon as possible with a layer of dry sand to retard its cooling, thereby producing facets of a

Fig. III



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larger and brighter form, sometimes as large as the palm of the hand. The cold pig-metal is very brittle and sonorous; the surface of the casts are concave, the fracture representing the silvery facets, and its mean specific gravity of F. 1500.

Having thus far described, to a limited extent, the materials which are used in producing the spiegeleisen, and the manner in which the smelting process is conducted, there still remains a great deal more to say; but space will not permit a review of the many points embraced in this subject. The study of periodical phenomena, the study of the physical conditions of the materials and of the action of other different physical agents, is a subject worthy the attention of iron-masters.

(Signed,)

HUGH HARTMAN.

DESCRIPTION OF FIGURE 1, PAGE 451.

The kilns of the shape like figure 1, require for roasting process 100 lbs. of waste coal to each 1000 to 1500 lbs. of spathic ore, 100 lbs. of waste coal to each 500 to 600 lbs. of aluminous ore, and are sufficient to produce $7\frac{1}{2}$ to 10 tons every 24 hours (about one-sixth to one-fourth of the contents of the kiln) of roasted ore. The loss, by calculation, of the spathic ore is equal to 21 to 25 per cent., of the aluminous ore is equal to 18 to 30 per cent. of moisture and other volatile matter. The spathic ore, as well as the aluminous ore, will attract some atmospheric moisture after being roasted, viz., the spathic ore from 2 to $2\frac{1}{2}$ per cent., the aluminous ore from 4 to 5 per cent. The average cost of roasting the two ores is about 35 cents per ton.

FIGURE 2, PAGE 455.

The coking furnaces are three feet four inches wide by four feet nine inches high in the centre, and twenty-four feet long. There are generally from thirty to thirty-six furnaces connected in a "battery," the gases of which are conducted by means of the channel A to four steam boilers of twenty-five feet in length and seven and a half feet in diameter, each one with two boilers of two and a half feet diameter. The

coke is cooled by means of water, of which about three gallons is required to each bushel of coke. The cost of the coking process is something over three cents per 100 lbs.

FIGURE 3, PAGE 460.

There are fifty-two pipes in each apparatus of the shape like Figure 3, (representing a cut through the center line of a pipe), which are divided by means of a partition into two parts, so as to enable the blast-air to ascend and descend in each pipe. The latter are each of a length of from 10 to 12 feet; the surface exposed to the fire is 2429 square feet, and the cubic contents of the 52 pipes 460 cubic feet.

FIGURE 4, PAGE 465.

The tuyeres are made of copper and cooled with water, which enters at A so as to bring the coldest water to a point as near as possible to the greatest heat; the warm water runs off at B. The plates D, supporting the tuyeres, are also cooled with water, which is poured in from time to time before it is entirely evaporated. The tuyeres are mostly of the dimensions shown in the figure. The noise pipes of cast iron are fixed by means of a key, C, and bear on their extreme end a rounded ring which, when brought forward as far as possible, entirely closes the tuyeres.

FIGURE 7, PAGE 470.

The water comes from a higher point so as to be under a certain pressure, and enters the first reservoir, which is made of cast iron and covered for the purpose of supporting also a part of the brick work of the furnace. This reservoir A (of larger dimensions than the lower ones) and the following B and C, surround the furnace entirely. They are made in four parts, to give opportunity to move them easily in cases of necessity.

The water runs from A to B and C like the water of a cascade, and from the last point K to a large reservoir, from which a pump takes the supply to the steam boilers. The reservoirs B, C, and D are of wrought iron, and E of stone or cast iron.

SPIEGELEISEN MANUFACTURING.

A few general remarks on the forming of the slag.

In commencing this second chapter I begin with a few general remarks on the great influence of chemistry in the metallurgy of iron.

No study can have a greater material significance than the one which gives a knowledge of the causes of accidents in the process of iron producing, and a knowledge of the means and natural laws which enables the iron master so to modify the working conditions of his blast furnace, that all the deficiencies and defects, which always will appear at times, can not deprive him of a certain success.

The history of scientific iron producing is particularly worthy of attention ; up to 1856 the directors placed at the head of iron manufacturing establishments in Germany and elsewhere, must be what people termed "practical men," and, according to such a principle, success would solely depend upon the practical skill and dexterity of men. But when new and greater demands were trying their knowledge and experience at a time when the want of iron increased by the development of railroads and every other kind of engineering work, and had reached dimensions previously unknown, it soon appeared that their experience, so highly prized, had lost its power over such new, and until then, unknown fields.

The years following after 1856 represent, therefore, a transition state of theory and practice, and while on the one hand too much reliance was placed upon the practical skill as the only attribute necessary, on the other, the theoretical skill was not more than in a state of development, and thus a very big struggle resulted in introducing science into the field of iron manufacturing.

At present, almost daily we read in the journals not only of experiments made, but of experience had under the guiding star of scientific skill, of chemistry ; a science almost unknown in such practical application some fifteen or twenty

years ago, and it is entirely safe to say that in our days the knowledge, the scientific knowledge of this art is the only ground upon which even practice can grow. I do not go too far in saying that knowledge of chemistry is the bottom of the modern system of iron producing.

The more one studies the course of development of the different manufacturing branches, and especially that of the iron which is called spiegeleisen, the more he will be impressed with the truth of this assertion. The success now before us is marvelous, and only scientific working was able to produce such unexpected results.

As mentioned in my previous letter, the mixture of the different ores and fluxes, or in other words, the chemical constitution of the slag resulting from the different earthen and silicious admixtures of the different ores and flux, form the ground upon which the whole process is founded.

The principal rule in forming the slag is to supply it with more bases than the chemical constitution requires. It is necessary to know beforehand what mineral element the slag requires, and it will appear at first sight a very simple matter to have this question determined, but in looking over the several analyses made of ore from the same mine we do not find such a uniformity of the constituents of the ores which is desirable to render them reliable once and for ever as exact statements. Extended analyses of the ores, even of different places of the same mine, are needed; for those made of one place can not be made a rule for another. Hence it is necessary that well managed iron works always should keep at hand a large stock of ores, classified regularly according to their chemical constitution; and furthermore, that a well trained chemist be incessantly at work furnishing the analysis of each new ore.

I know there are, even in this country, many iron-masters who will laugh at such a conscientiousness, but I know by experience that, whatever any one may think about this assertion, it most assuredly can not be denied that all powers of the iron-masters in Germany, Belgium, and England are now concentrated in the laboratory, and this not

Fig. 16

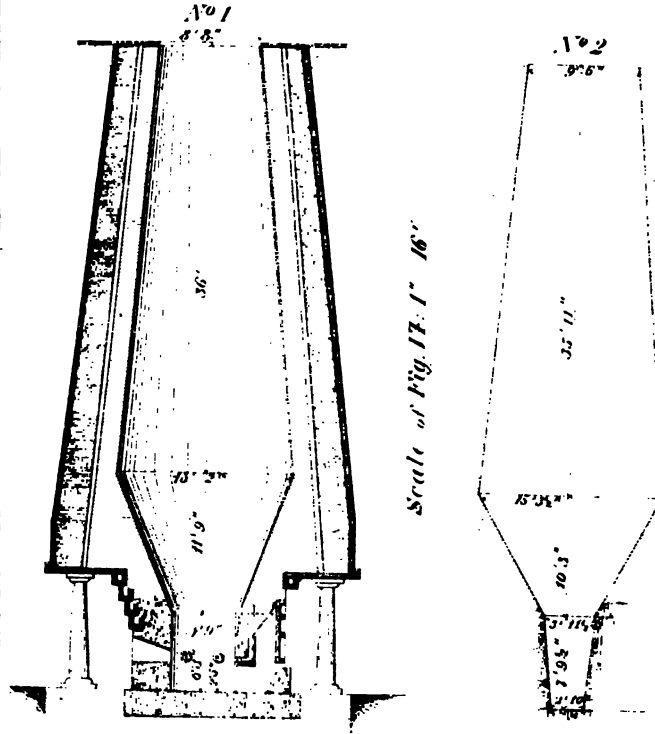
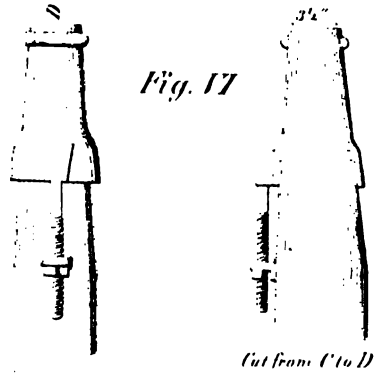


Fig. 17



Scale of Fig. 17. 1" = 16"

without success. The magnificent "glittering" iron which they produce is my proof.

THE CONSTITUTION OF THE 'SLAG' CHEMICALLY EXPLAINED.

It is not necessary to tell here the reasons why the different kinds of fuel (charcoal or coke) require each another rule for forming the chemical constitution of the slag. It is sufficient to say, because every iron-master knows this, that a blast furnace supplied with charcoal as a reducing agent requires a slag of the formula—

Oxygen of the acids : Oxygen of the bases, = 2:1; while the slag of a furnace supplied with coke must be of the proportion—

Oxygen of acids : Oxygen of the bases, = 1:1.

In the practical working the slag, which results, very seldom reaches this chemically calculated point accurately, but comes as near as possible to it, and I may say it is of the greatest importance that the management of the working conditions of the furnace permits extended variations, because without such possibility each management itself would be merely a chimera.

In every case where only lime can be used for introduction as a base to the silica, the strictly chemical, above mentioned, constitution (1.1) of the slag is without any question the best point in view, and I may mark this constitution by means of the formula: $\text{Ca}^1\text{O}_3, \text{Si}^1\text{O}_3$. But as stated before, the more other earthen bases are in the one itself, the more they serve the purpose of forming a well-natured, fusible slag, i. e., a compound with the silica. Particularly these earthen bases allow a deviation from the formula, by using coke for fuel, extending within the limits—

From R_2S_2 to R_2S_3 , even to R_2S^x .

Or otherwise expressed,

From Oxygen of the bases : Oxygen of the acids, = $1\frac{1}{2} : 1$ or $1 : \frac{2}{3}$.

G. R.—30

THE QUANTITY OF THE SLAG COMPARED WITH THE
AMOUNT OF IRON.

Of the greatest influence in producing glittering iron is furthermore the quantity of the slag (by weight) compared with the quantity of iron; and it is proved by experience that the relation between these two materials being 1 : 1 is the best.

For when it would be more like,

1st. $\frac{Fe}{1} : \frac{Slag}{2}$, the working affairs of the furnace in general would be good enough, but a too large mass of slag always injures the iron by diminishing its quality in impregnating the same with too much silica. We know a certain amount of silica is of the greatest influence in the Bessemer process, but too much is also an evil, and it rests with the experience of the iron producer to determine this required amount of silica. At the same time a too large quantity of slag will afford too much carbonic matter for its own smelting, which would be worse than every other accident in the Spiegeleisen producing, because the forming of the constitution = Fe, C , requires a great amount of superfluous carbon.

2d. $\frac{Fe}{1} : \frac{Slag}{4 \text{ or } 5}$ would be an unfavorable relation because there is not enough of the slag to cover the iron and protect it against combustion and decarbonization. The higher the pressure of the blast-air, the larger the quantity of slag required and I mentioned before that the usual pressure is from two and a half to three pounds per square inch.

It is therefore entirely erroneous, as some of the iron masters used to do, in working with a very hot blast-air to economize with the lime flux, because in every such case the quality of the iron will be deteriorated.

Of the greatest influence in forming the slag is also the Manganese.

One part of the Mn. O. forms with different other siliceous compounds a very fusible slag; another part of the oxidated manganese will lose its oxygen and join the iron, but of this part only another smaller portion remains. During a certain period of the cooling of the iron one can

observe the withdrawing of a more or less thin, scaly and blistery layer on the surface of the iron which is found to be composed of Mn. O, Si. O₃ together with a small portion of Fe O, Al₂ O₃, and other bases. The compounding of the manganese and silica with oxygen, viz.: Mn. O. and Si. O₃, takes place only at a time when the atmosphere adds to the molten iron, so that the latter is enabled to join with the oxygen, for there is, without any question, in the molten iron only Mn. and Si. This peculiarity of the manganese to join the silica in the iron, forming Mn Si, which is of less specific gravity than the iron, gives the highly esteemed value to the manganiferous pig metal.

The next circumstance which has to be considered in this connection is the relation of

THE ALUMINOUS ORES

to the slag. The alumina acts as a base in regard to the silica whenever the latter is preponderating, and therefore an admixture of aluminous ore is as much an importance in producing the slag as the carbonate of lime.

Having so far explained the general points which the iron master should take into consideration when forming the calculations, I shall now proceed to point out especially the manner in which such a calculation is to be made:

The figures in the following tables are only supposed ones, for iron masters know that bringing entirely correct statements before the public would be an indiscretion, nevertheless they represent strictly the mode of operating.

Say the analysis of several ores are the following:

TABLE I.

	I Spathic Ore roasted.	II. Red Hematite.	III. Brown De- composit'n.	IV. Alumin- ous Ores.
Oxide of Iron	60.10	71.89	71.30	38.40
Silica	18.27	13.99	15.85	37.40
Lime	5.64	2.17	Trace.	9.12
Magnesia	2.04	1.25	2.05	2.10
Alumina	.50	1.27	1.20	7.98
Ox. Manganese	7.00	8.13	.....	1.26
Sulphur	.35	.....	.....	.14
Phosphorus .....	.....	.....	.14	.20
Water	.35	1.38	10.10	4.00
	100.25	100.21	100.64	100.00

As shown in the previous letter from these different ores are taken

Of No. 1 - - - - 38 per cent.
 Of No. 2 - - - - 30 per cent.
 Of No. 3 - - - - 20 per cent.
 Of No. 4 - - - - 12 per cent.

100

For mixture, and therefore the figures of Table I have to be calculated in accordance with this ratio. , The product will be in hundred parts of mixed ore :

TABRE NO. II.

	No. I.	No. II.	No. III.	No. IV.	In 100 lbs
Oxide of Iron.....	25.12	21.57	14.26	4.37	65.32
Silica	6.94	3.92	3.17	4.48	18.51
Lime	2.14	.65	.....	1.09	3.88
Magnesia	.77	.37	.41	.37	1.92
Alumina.....	.19	.41	.24	.96	1.80
Oxide of Manganese.....	2.68	2.43	.....	.16	5.25
Sulphur	.13	.....	.....	.02	.15
Phosphorus.....	.....	.....	.03	.06	.09
Water	.13	.42	2.02	.98	3.05
Total	38.08	29.47	20.13	11.99	99.97

Henceforth these:

Oxide of Iron,	65.32 contains 41.76 per cent. metallic iron.	
Silica, - - -	18.51 contains oxygen, - -	9.80
Lime, - - -	3.88 contains oxygen, -	1.17
Magnesia, - -	1.92 contains oxygen, -	.76
Alumina, - -	1.80 contains oxygen, -	.84
Oxide of Manganese,	5.25 contains oxygen, -	1.18
Sulphur, - -	.16 contains oxygen, -	.....
Phosphorus, - -	.09 contains oxygen, -	.....
Water, - - -	3.05 contains oxygen, -	.....
	99.97	35.9 9.80

The formula of the Singulo Silicate requires that the oxygen of the bases should be 9.80, but being only 3.95 there is a deficit of 5.85, which is contained in 20.48 Ca O, or in 36.57 Ca O, C O₂; the lime used as a flux contains 98 per cent. Ca O, C O₂; therefore, 98 : 100 :: 36.57 : 37.32 per cent. of carbonate of lime for a fluxing agent.

To show the correctness of this calculation, the lime has to be added to the mixture of ores.

In 100 parts of the Ca O, CO₂ are—

98.00 Ca O, C O ₂ , therefore in 37 parts	36.57
1.50 Si O ₃	.55
.50 water.....	.02

Omitting the $C O_2$, which will be withdrawn in the furnace, the slag will contain the following constituents :

Oxide of Iron.....	65.32 x	=	65.32	=	47.68	=	33.00	Fe
Silica	18.51 x	.55	=	19.06	=	13.91	with	O=.737
Lime.....	3.88 x	20.48	=	24.36	=	17.78	=	5.07
Magnesia.....	1.92 x	=	1.92	=	1.40	=	.56	
Alumina.....	1.80 x	=	1.83	=	1.34	=	.62	
Oxide of Mangnese.....	5.25 x	=	5.25	=	3.33	=	.86	
Sulphur.....	.15 x	=	.15	=	.11	=		
Phosphorus.....	.09 x	=	.09	=		=		
Carbonic acid.....	x	16.99	=	16.99	=	11.74	=	
Water.....	3.05 x	.18	=	3.23	=	2.35	=	
			99.97		38.20		137.30	
						100.14	7.11	7.37

We see, therefore, that the constitution of the slag will bear the proportion Oxygen of the Bases 7.11 : Oxygen of the Acids 7.37.

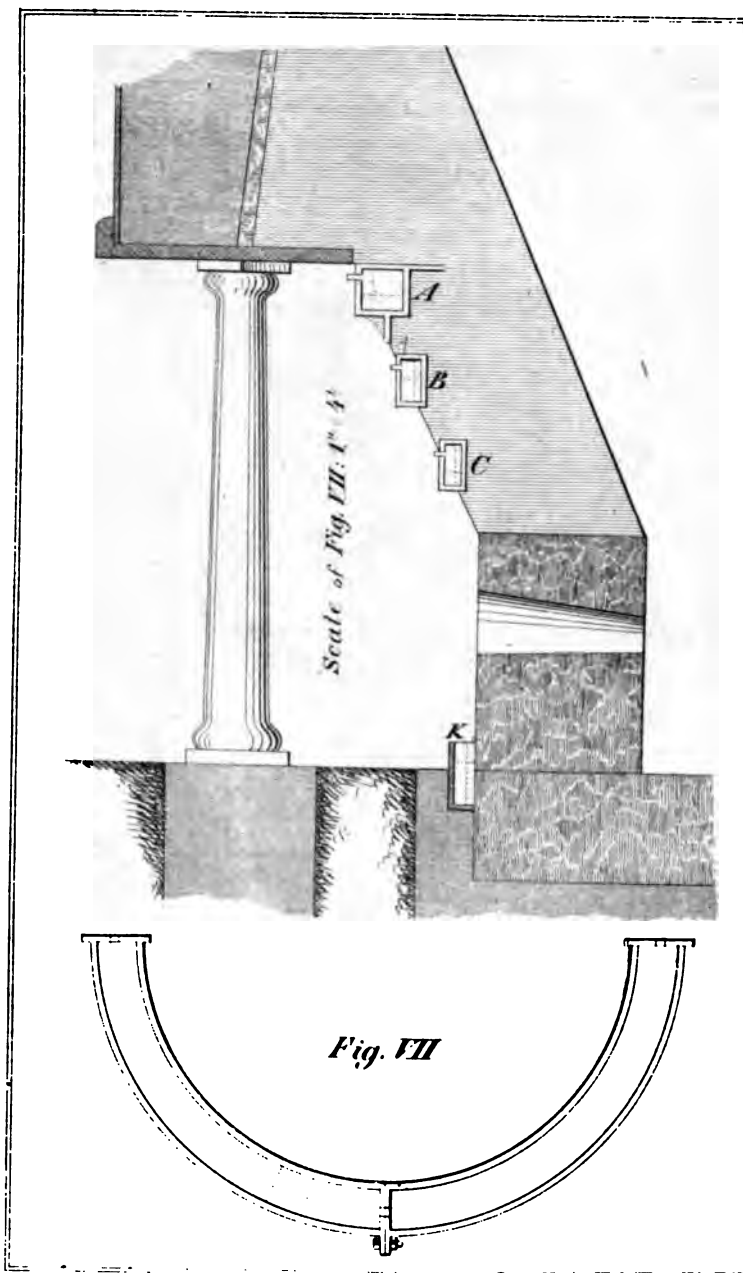
In regard to the quantity of the slag, the slag forming materials are represented by :

Silica.....	13.91
Lime.....	17.78
Magnesia.....	1.40
Alumina.....	1.34
	34.43

and the proportion of the slag to the iron is 34.43 to 33.06, being nearly equal.

These data explain fully the way in which the iron master forms his idea of the materials which he intends to bring into his blast furnace; nevertheless it is safe to say that in the working of the furnace many revolutions will appear which may seriously disturb this mode of operation, and therefore it is certain that theory without practice is worth no more than practice without theory; but this, I repeat, is the only true means of finding out, in the shortest time, the real causes of disturbance and irregularity.

Making use of the foregoing explanation in regard to the spiegeleisen, there is the first rule in composing the ores to



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a good slag. Each slag will be of the most fusible nature, which is composed of more than one earthen base with silica, because such compounds act as fluxes on each other. And experience has proved that ores of a refractory character are more easily worked when mixed with other ores than when mixed with lime alone.

There are still three general remarks to be added :

1st. That neither the slag be too infusible.

2d. Not fusible enough.

3d. Not to accumulate too much ore in fulfilling the first condition in the spiegeleisen manufacture mentioned before.

To commence with the latter remark, there will not be heat enough in the furnace to produce Fe. 4 C., and, extended to a larger scale, even not heat enough to reduce the ores. The signs of a coming disaster, like this, are indicated by a slag which bears a glassy appearance throughout the whole mess, changing, by and by, to a dark-brown porous mass. This crude slag is at first very fusible, cools very quick, and after a few hours flows very slowly and thickly over the damstone, the tuyeres become darker, and the flame at the tunnel-head is very red and hot. The best remedy in such a case is less blast-air, a few charges of coke only, and smaller charges of ore.

If the mixture of flux and ore be too fusible, then the ores will melt before they are entirely reduced, the slag can not protect the iron from combustion in the vicinity of the tuyeres, and it will, therefore, be reduced to Fe O, which renders a dark black slag. The tuyeres will be clear but not clean, requiring frequent mechanical cleaning; the forming of a mass of unreduced ores and slag takes place in the centre of the furnace, which one can not see on account of the bridle tuyeres, but which can be easily observed by means of an iron bar thrust into the furnace through the openings in the tuyeres. The first indications of such a crude working state of a furnace are found in a quicker, irregular going down of the charges at the mouth of the furnace, and only less blast air but of higher pressure, forcing the charges to go down slower, is a remedy in this case,

until there is found opportunity to change the mixture of ores of flux.

The constitution of the mixture, where it is not fusible enough, produces a black slag indicating that the same involves the iron in the vicinity of the tuyeres, hindering its reduction; the heat decreases in the furnace. The best remedy for this state of affairs is more blast air with the same width of the nose pipes, less ore and flux.

I may now bring this letter to an end, but can not omit to say that the first development of the Spiegeleisen manufacturing, by means of coke, was attended by many difficulties, which at times seemed almost insurmountable. The first trials were met with many and great difficulties, calling forth the highest skill of the engineers, and at the same time with many expressions of doubt; and when at last it was definitely known that the science of metallurgy had overcome the greatest obstacles, there still remained in the minds of iron-masters an aversion to the new metal. The iron had to be introduced into the market and its merits made known, and iron-masters, reluctant to experiment with a material of such different quality from that they had been accustomed to use, must be induced to try the new metal. The first thing was to test its value, and bring it to the favorable notice of the iron-masters, experiments were made and proved that its freedom from sulphur and phosphorus, on the one hand, and the presence of manganese on the other, produced a metal unequalled in value by any known to commerce, except the small quantity produced by means of charcoal. Quantities of the new iron were soon introduced into the rolling-mills and other works, and the unanimous verdict of all who tried it was to the effect that it was preferable to the best iron previously known, and the only kind which would enable Bessemer steel manufacturers to bring into execution his (Bessemer's) manner of manipulating. Ever since that time the demand has exceeded the supply.

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ERRATA.

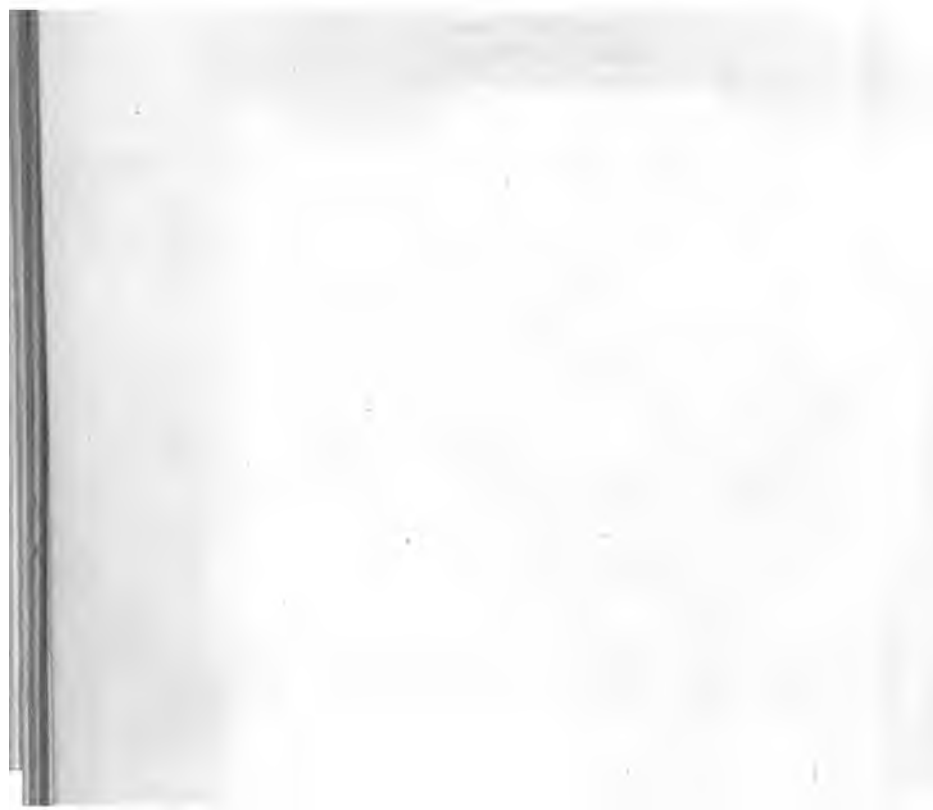
- Page 28, 20th line, for "4.5" read "4.05."
Page 32, 5th line, for "Standard" read "Pioneer."
Page 32, 8th line, for "Standard" read "Pioneer."
Page 32, 11th line, for "Standard" read "Pioneer."
Page 32, 14th line, for "Standard" read "Pioneer."
Page 32, 24th line, for "4.09" read "8.09."
Page 35, 25th line, for "per cent.," under the word "undried," read
"evaporate pounds of water," and read the same under the word
"dried" in the same line.
Page 39, 14th line, for "when" read "where."
Page 67, 7th line, for "generous men" read "gentlemen."
Page 71, 10th line, insert "Loess" after "quaternary."
Page 77, 6th line, for "palæchinus" read "palæechinus."
Page 77, 8th line, for "valley" read "valleys."
Page 81, erase "Upper Archimedes limestone" in section.
Page 93, coal F, in section, is 4 feet thick.
Page 102, 13th line, for "was" read "is."
Page 107, 7th line, after "coal" insert "K."
Page 107, 11th line, for "but" read "and."
Page 107, 12th line, for "too great a" read "to a great."
Page 107, 30th line, for "of" read "at."
Page 138, 18th line, for "this" read "the Loess."
Page 155, 32d line, for "island" read "inland."
Page 187, 11th line, for "Meinrod" read "Meinrad."
Page 193, 32d line, for "intercolations" read "intercalations."
Page 199, 3d line, erase the word "inclusive."
Page 199, 25th line, for "bed" read "led,"
Page 199, 26th line, erase; after "layers."
Page 200, 15th line, for "the by" read "by the."
Page 200, 20th line, for "the" read "this."
Page 203, 37th line, after "supply" insert "afforded."
Page 204, 9th line, for "southwest" read "southeast."
Page 207, 6th line, erase "county."

- Page 211, 1st line, for "McCane" read "McCain."
- Page 218, 5th line, for "Stigmara, Fucoides" read "Stigmara ficoides."
- Page 221, 21st line, for "Laughbemies" read "Laughbenner."
- Page 227, 18th line, for "bividents" read "bovidens."
- Page 231, 23d line, for "Vora" read "vorax."
- Page 234, 8th line, for "following" read "flowing."
- Page 235, 16th line, for "as" read "are."
- Page 247, 20th line, for "Piscina" read "Discina."
- Page 247, 21st line, insert comma after "Productus."
- Page 248, 11th line, insert "it" before "is."
- Page 250, erase 3d and 4th lines and first half of 5th.
- Page 263, 7th line, for "Demetts" read "Demotts."
- Page 264, 36th line, for "Taylor" read "Traylor."
- Page 273, 19th line, for "partings" read "divisions."
- Page 275, 29th line, for "Heuke" read "Henke."
- Page 276, 20th line, for "shale" read "clay."
- Page 279, 12th line, for "To the southeast of Snake Knob, seven miles distant, is seen Detney Hill, twelve miles southsouthwest. Stendal, eleven miles due east," read "Seven miles to the southeast Snake Knob is seen, twelve miles southwest is Detney Hill, and Stendal eleven miles due east."
- Page 280, 16th line, erase semicolon after "beneath."
- Page 283, 10th line, for "quantity" read "quality."
- Page 286, insert "which" after "and."
- Page 287, 25th line, for "to" read "of."
- Page 295, 16th line, for "Pentramites" read "Pentamerus."
- Page 300, 17th line, for "Metanonongs" read "Monons."
- Page 302, 10th line, for "athyris" read "and Athyris."
- Page 302, 29th line, for "legathephylleice" read "Cyathophylloid."
- Page 302, 37th line, for "Orthocera" read "Orthocerata."
- Page 304, 32d line, for "running" read "mining."
- Page 305, 16th line, for "Mound" read "Monon."
- Page 305, 31st line, for "Knobston" read "Knobstone."
- Page 306, 9th line, for "alluvium" read "clay."
- Page 306, 19th line, for "pentamorous" read "pentamerus."
- Page 307, 8th line, for "auritisma" read "euritines."
- Page 307, 9th line, for "setigara" read "setigera."
- Page 307, 10th line, for "Pentamorous" read "Pentamerus."
- Page 307, 17th line, for "their" read "these."
- Page 307, 22d line, for "Pentamorous" read "Pentamerus."
- Page 307, 34th line, for "variety, the" read "the variously."
- Page 308, 1st line, for "beaches" read "benches."
- Page 309, 17th line, for "Pentamorous" read "Pentamerus."
- Page 312, 24th line, for "polymorphia" read "polymorpha."
- Page 315, 20th line, for "dumosem" read "dumosum."
- Page 315, 21st line, erase comma after "Calymene."
- Page 315, 28th line, for "ou" read "an."

- Page 316, 7th line, for "Rosa" read "Rose."
Page 316, 19th line, for "dam and mill" read "demand will."
Page 316, 30th line for "Falry" read "Farley."
Page 316, 32d line, for "train" read "tram."
Page 317, 31st line, for "Zygospira" read "Zygospira."
Page 318, 5th line, for "expanse" read "exposure."
Page 318, 31st line, for "Shelby's" read "Shelly's."
Page 319, 16th line, for "fire" read "bore."
Page 319, 23d line, erase "jeler."
Page 319, 29th line, for "stem" read "stone."
Page 321, 6th line, for "south" read "north."
Page 321, 21st line, for "rocky band" read "lime rock bed."
Page 322, 4th line, erase comma after "Bumastia."
Page 322, 34th line, for "Lyde's" read "Lynch's."
Page 323, 6th line, for "building" read "burning."
Page 323, 16th line, for "supremacy" read "existence."
Page 323, 20th line, for "infringes against" read "impinges on."
Page 324, 17th line, for "division" read "deposit."
Page 325, 33d line, for "sand-" read "mud-."
Page 327, 25th line, for "at" read "in."
Page 327, 27th line, for "city" read "county."
Page 328, 11th line, for "J. H. Pettit" read "J. U. Pettit."
Page 330, 14th line, for "lime" read "lower."
Page 332, 32d line, for "Athyrus" read "Athyria."
Page 335, 7th line, for "Gleeson's" read "Greeson."
Page 335, 30th line, for "successive" read "several."
Page 336, 8th line, for "Detenbaugh's" read "Defenbaugh's."
Page 336, 11th line, for "west" read "water."
Page 336, 13th line, for "Detenbaugh's" read "Defenbaugh's."

From page 189 to 336 of this report, the author had no opportunity of correcting the proof sheets, which accounts for many of the errors in text and orthography.

The numbers referred to on page 199, line 19; page 204, line 13; page 207, line 17; page 211, line 18, were originally attached to the different divisions of the "General Section," but were omitted for want of room on the pages.



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